OCTOBER 22, 2015

UNIVERSITY OF TWENTE

Drienerlolaan 5, 7522 NB Enschede

A method for information waste identification: Designed and tested at Company X

Author: Niels Getkate
s1240773
Master Business Administration
Behavioural, Management and Social Sciences

Supervisors: Dr. A. B. J. M. Wijnhoven
Dr. Ir. E. Hofman

Abstract

The continuous improvement of manufacturing and production systems has long been of central interest to both managers and management researchers. As a consequence, lean thinking has become a well-known term for those interested. The principles of lean thinking and in particular the removal of waste and pursuit of perfection can be applied to any system where product flows to meet the demand of the customer, user or consumer. However, there is a lack of supportive methods for improving the overall information management system and infrastructure. The aim of this study is to identify the characteristics of lean information processes. For the purpose of this study, a method for information waste identification was developed. This method was applied at Company X. The project was designed to review the company's key performance related-information processes on information waste. On the basis of the results of this research, it can be concluded that in order to prevent information processes from information waste, the flow of information elements should be in line with the needs of the information consumer. Furthermore, the information elements should be accurate, reliable and up-to-date. Above all, organisations should make sure they are able to identify information needs. Therefore, an effective method for identifying and eliminating information waste in management reports, should be able to distinguish relevant from irrelevant information. Besides, it should be able to detect whether or not relevant information is available. Finally, the method should be able to identify inefficiencies in the information processes.

Keywords: Lean information management, information waste, key performance indicators, balanced scorecard, business process modelling

Preface

In front of you lies a copy of the master thesis 'A method for information waste identification: Designed and tested at Company X'. This report is part of the final stage of the master Business Administration at the faculty Behavioural, Management and Social Sciences from the University of Twente. It describes a research carried out at Company X with the main topic of information waste identification.

According to Larson (2005), the activities of information management can be considered to involve the creation, representation, organisation, maintenance, visualisation, reuse, sharing, communication and disposal of information (as cited in Hicks, 2007, p. 233). Since inefficiencies are detrimental to the performance of organisations, it is desirable that these activities are performed efficiently and with the minimum of waste (Hicks, 2007). There is however a lack of supportive methods for improving the overall information management system and infrastructure. This research project contributed to designing and testing a method for information waste identification in Company X's key performance related-information processes.

At this moment when my research project is finished, I want to thank multiple persons. First of all, I want to the technical director at Company X, for giving me the opportunity to carry out this project and for his support during the completion of the research. Next, I want to thank my supervisors from the University of Twente, Fons Wijnhoven and Erwin Hofman. Their valuable feedback and advice during the research assisted me to focus on the right direction and in the achievement of a rewarding academic level.

The completion of this master thesis could not have been carried out without the support of various persons of Company X, who have directly or indirectly contributed to a successful completion of this research project. Lastly, I want to express my gratitude to my family, friends and my love for their support during my graduation, but also during the duration of my study. Without their valuable information and advices it would have been much harder to obtain my master's degree.

Niels Getkate

October, 2015

Table of contents

List of abbreviations

BPM	Business process modelling
BSC	Balanced scorecard
CSF	Critical success factor
DOH	Days on hand
FTE	Full time equivalent
KPI	Key performance indicator
LMS	Logistic monitoring system
OPM	Operational performance meeting
OTC	On time completion
OTD	On time delivery
PP	Previous period
PPV	Purchasing price variance
SME	Small to medium-sized enterprise
SROI	Social return on investment
SSR	Special sales request
TP	This period

List of figures

List of tables

List of equations

1. Introduction

1.1. Company X

Due to confidentiality, Company X cannot be introduced.

1.2. Problem statement

The problem statement is outlined first, after which the research goals and –questions are formulated and the research design is described. Until approximately one year ago, there was a monthly staff meeting where the department managers of Company X presented the key performance indicators (KPIs) of their departments. These meetings were abolished, because they resulted in a lot of spreadsheets which were not actually used. The first underlying cause was that the technical director and certain department managers had, and still have, doubts about the relevance of the KPIs. Every month, the company has to report specific KPIs to the division. These indicators are not derived from Company X's own organisational objectives, as it should be according to Kaplan and Norton (1996) and many other researchers, but determined by the holding.

Secondly, the technical director has doubts about the quality of the information. Information quality, which is mostly defined as reliable, accurate and up-to-date (Wang and Strong, 1996; Zmud, 1978; Jarke and Vassiliou, 1997; Delone and McLean, 1992; Goodhue, 1995; Ballou and Pazer, 1985), has become a critical concern of organisations and an active area of research. The direct access of information from various sources by managers and information users has increased the need for, and awareness of, high quality information in organisations (Lee, Strong, Kahn & Wang, 2002). Company X found out they used information for a certain KPI from someone who did not know his information was used. This person did not update the information frequently, while the KPI was updated weekly. Because this information process was not organised well, the information was not reliable, accurate and up-to-date.

According to Larson (2005), *"the activities of information management can be considered to involve the creation, representation, organisation, maintenance, visualisation, reuse, sharing, communication and disposal of information"* (as cited in Hicks, 2007, p. 233). It is desirable that these activities are performed efficiently and with the minimum of waste (Hicks, 2007). As discussed in the previous sections, there are doubts with regard to the relevance of the KPIs and the efficiency of the information processes. These information inefficiencies are detrimental to the performance of the company and therefore should be dealt with. Figure 1 visualises the problem statement.

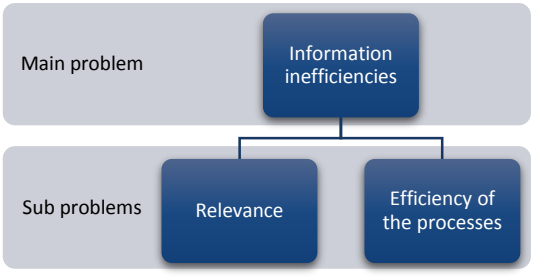

Figure 1. A visualisation of the problem statement.

1.3. Research goals and questions

According to Hevner, March, Park and Ram (2004), new insights in the field of information management can be constructs, models, methods or instances. Constructs consist of new notations

or symbols. Together, they form the language with which reality is described and solutions are designed. An example of a construct is the entity-relationship notation. This notation can be used to design a database, which is an example of a model. Methods on the other hand, are specifications of design processes. They tell how to use constructs to effectively make models. Methods can also be used to design instances, which are implemented models (Hevner, March, Park & Ram, 2004).

There are numerous techniques that support continuous process improvement of manufacturing and production systems, like lean thinking, Kaizen and Six Sigma. There is however a lack of supportive methods for improving the overall information management system and infrastructure, even though *"the principles of lean thinking and in particular the removal of waste and pursuit of perfection can be applied to any system where product flows to meet the demand of the customer, user or consumer (another system)"* (Hicks, 2007, p. 237). The scientific goal of this research project is to design a method for improving information processes by means of applying some lean philosophies to this context. By means of identifying and reducing information waste, the efficiency of the information processes can be ensured. The practical goal is to test the method at Company X in order to identify focused improvements on their KPI-related information processes.

In line with the research goals of this project, the central question that will be answered is:

What are the characteristics of an effective method for identifying and eliminating information waste in management reports?

To provide an answer to this question, it is necessary to determine the characteristics of lean information processes of an organisation. The philosophy of lean thinking involves linking all steps that create value, and eliminating waste and unnecessary actions. Hicks (2007) used the five principles of lean thinking (value, value stream, flow, pull and perfection) to develop a strategy for lean information management. First of all, value should be defined precisely from the perspective of the end-user. Secondly, the value stream should be mapped. Thirdly, waste and unnecessary actions should be eliminated. Fourthly, improvements on information and additional functionality should be designed. Lastly, the information system, all associated infrastructure and processes should be regularly reviewed (Hicks, 2007). The developed sub questions reflect the first four principles of lean information management. The last principle is not translated into a sub question, because this whole research project actually focuses on the design of an effective method for reviewing information processes on information waste. The sub questions are:

1. *What is the value of information from the perspective of the end-user?*
2. *What is the current situation with regard to the information processes?*
3. *What is the optimal situation?*
4. *Which improvements can be implemented to reach the optimal situation?*

This research project is structured according to these four sub questions. The first sub question reflects the first lean principle, defining the value of information from the perspective of the end-user. Company X wants information that supports their activities and ability to undertake work, where work may be defined as those activities that add value to either the product or service delivered by the organisation and ultimately the customer (Hicks, 2007). If Company X makes use of irrelevant KPIs, they produce information that does not support their activities and ability to undertake work. Therefore, the company's KPIs will be identified and assessed by means of a balanced scorecard (BSC) analysis. With this method, strategic objectives can be determined, after which the KPIs can be

assessed and (if necessary) new KPIs can be developed. In this way, the value of information from the perspective of Company X is defined. This should solve the first sub problem: relevance. Secondly, the information processes will be modelled with business process modelling software called Bizagi. The modelling of the KPI-related information processes of Company X is in line with the second lean principle, mapping the current situation. According to the third lean principle, waste and unnecessary actions should be eliminated. The categories of waste developed by Hicks (2007) will be used to identify information waste in the information processes. This analysis serves as the foundation for improvements, the fourth sub question. These actions together should ensure the efficiency of the information processes, the second sub problem. Figure 2 gives an overview of the structure of this research project.

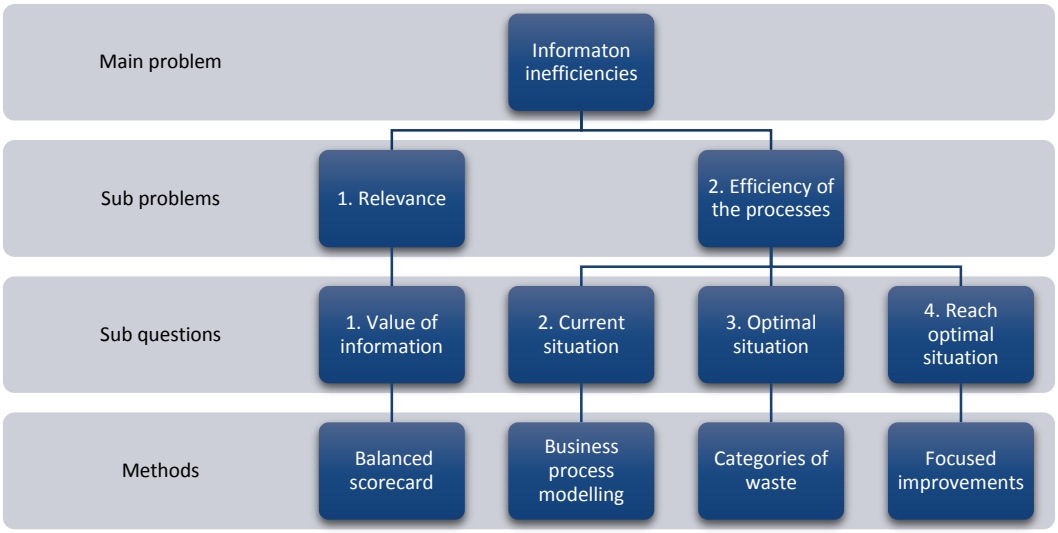

Figure 2. An overview of the structure of this research project.

1.4. Research design

Van Aken (2004) argued there is a distinction between description- and prescription-driven research. First-mentioned research is having an explanatory nature and is used largely in a conceptual way. This project involves prescription-driven research, which is used largely in an instrumental way to design solutions for management problems (also known as design knowledge). Design knowledge is built up through van Aken's reflective cycle: choosing a case, planning and implementing interventions (on the basis of the problem solving cycle), reflecting on the results and developing design knowledge to be tested and refined in subsequent cases. The problem solving cycle consists roughly of defining the problem out of its context, planning the intervention, applying the intervention and evaluating (Van Aken, 2004). The design process (a method for information waste identification) will go through a stage of α-testing, which is an analysis of the effectiveness of the method in the original context. Invaluable insight can be gained by subsequent β-testing. This means translating the method to other contexts, having third parties use it to assess its effectiveness and make final improvements (Van Aken, 2004). The α-testing will take place at Company X. The company is already described in the previous sections. The departments that will be taken into account are Order Management, Series Support & Industrial Engineering, Production Scheduling, Purchasing, Warehousing, Production Manufacturing, Production Assembly and Quality Management. These departments account for nearly all the people working at the production site. The subjects under study are those who are

involved in the KPI-related information processes. The method for information waste identification is described and explained in the third chapter.

2. Theoretical framework

The method for information waste identification is developed for identifying and reducing information waste in the KPI-related information processes of Company X. The method starts with assessing the relevance of Company X's current KPIs. Secondly, the related information processes are reviewed on information waste, after which solutions to information waste are developed. This means the theoretical framework of this research project outlines literature about respectively KPIs, performance measurement methods (in particular the BSC) and information waste.

2.1. Key performance indicators

The measurement of the performance of organisations has long been of central interest to both managers and management researchers. As a consequence, management control systems have become a well-known term for those interested. In broadest definition, management control systems provide both financial and non-financial information on both internal and external factors, to managers for the purpose of control and decision-making (Chenhall, 2003). These systems use many techniques for collecting and using information in order to evaluate performance. Kaplan and Norton's BSC is probably the most famous one. This method is defined as a set of measures that gives top managers a fast but comprehensive view of the business, including both financial and operational measures (Kaplan & Norton, 1992). When there is a need to understand well what is important, techniques such as the BSC are a very common way to choose KPIs.

Nowadays, many organisations use KPIs to measure their performance. However, Parmenter (2007) stated that relatively few of them really know what KPIs are. This researcher argued that at most organisations, KPIs are a mix of critical success factors (CSFs), key result indicators, performance indicators and KPIs. According to Parmenter (2007), CSFs determine the organisational health and vitality and where the organisation needs to perform well. CSFs are the factors that are decisive for achieving or not achieving organisational objectives; key result indicators, performance indicators and KPIs are the actual measures. Key result indicators tell an organisation what they have done in the past, while performance indicators tell them what has to be done now. KPIs, on the other hand, tell an organisation (in particular its managers) which daily activities need to take place to increase performance dramatically (Parmenter, 2007). In other words, *"KPIs represent a set of measures focusing on those aspects of organisational performance that are the most critical for the current and future success of the organisation"* (Parmenter, 2007, p. 3). According to this researcher, the seven characteristics of effective KPIs are:

- Nonfinancial measures: not expressed in a currency (then the KPI is already converted into a key result indicator)
- Timely: measured frequently, for example 24/7, daily or weekly
- Chief executive officer (CEO) focus: acted upon by the CEO and senior management team
- Simple: all staff understand the measure and what corrective action is required
- Team based: responsibility can be assigned to a team or a cluster of teams who work closely together
- Significant impact: it affects more than one of the organisation's cash flows and more than for example one BSC perspective

- Positive impact: affects all other KPIs in a positive way

It is commonly acknowledged that KPIs should reflect and be derived from an organisation's strategic objectives. KPIs can be distinguished from objectives as, what their name already suggests, that they are only indicators which measure progress towards and achievement of certain objectives. Therefore, each indicator should be based on criteria that make it suitable for further analysis (Shahin & Mahbod, 2007). The set of criteria most often referred to is SMART. This abbreviation stands for specific, measurable, attainable, realistic and time-bound (Doran, 1981). These criteria work, because setting specific objectives forces an organisation to search for precision. It removes ambiguity and forces hidden agenda items into view. Moreover, measurable objectives define the quality measure against which the objective can be evaluated. This allows an organisation to measure and report on the progress. Furthermore, attainable objectives establish expectations and reduces politics, whereas realistic objectives help prevent cost and schedule overruns, which in turn ensures that project scope will be achieved. Finally, time-bound objectives establish clients and stakeholder expectations (Richman, 2011).

Furthermore, performances can be measured at multiple levels (Barr, 2010). According to Barr (2010), any organisation has some levels of performance indicators that interdependently sum up what the business must improve as it moves into the future. Barr (2010) argued that there are four common layers in any organisation's hierarchy, namely sustainable, strategic, tactical and operational KPIs. Sustainable KPIs are those indicators implied by an organisation's vision, mission and ultimate outcomes for their stakeholders. Examples of such KPIs are profit and customer loyalty. Strategic KPIs basically describe what an organisation is going to be like in the near future (2-5 years from now). Examples are return on investments, market share and revenue. Tactical KPIs are derived from an organisation's core processes, which are the processes that have a significant impact on their performance. Examples of tactical KPIs are product sales, lost time injuries and on time delivery to customers. Operational KPIs often track the main causes of tactical indicators. As Barr (2010) described it, *"they are the drivers of the whole-process results and are where resources are allocated to improve process performance and ultimately improve organisational success and sustainability".* Rework, incidents, accidents and inventory turn are examples of operational KPIs. Barr (2010) stated that each KPI has a relationship with at least one other indicator. Seeing these relationships makes it easier to see gaps in an organisation's strategy. Therefore, mapping relationships among the levels of an organisation's KPI hierarchy can be valuable.

Although Company X has a rather extensive list of KPIs, the company cannot ensure its relevance and completeness, mainly because these KPIs are not derived from Company X's own strategic objectives, but imposed by the holding. This means it is possible that they do not reflect the company's strategic orientation. To ensure the company produces information that supports their activities and ability to undertake work (value-adding information), a BSC analysis will be conducted. After the choice for this method over other performance measurement methods is justified, the BSC will be introduced. How the BSC will be applied, is discussed in section 3.1.

2.2. Performance measurement with the BSC

During the years, numerous performance measurement methods have been developed. Taticchi, Tonelli and Cagnazzo (2010) conducted a list of twenty-five methods, which can be found in table 1. As you can imagine, the large number of performance measurement methods makes it difficult to choose which one to use. Therefore, the methods were filtered on two criteria. The first criterion was

that the method had to be implemented or tested during scientific studies. In this way, the risk that a chosen method contains mistakes or validation issues was taken away. The second criterion was that there had to be access to articles that describe the method.

Year of introduction	Name of the method	References
Before 1980s	The ROI, ROE, ROCE and derivatives	Simons (2000)
1980	The Economic Value Added Model (EVA)	Stewart (2007)
1988	The Activity Based Costing (ABC) – The Activity Based Management (ABM)	Cooper and Kaplan (1988)
1988	The Strategic Measurement Analysis and Reporting Technique (SMART)	Cross and Lynch (1988)
1989	The Supportive Performance Measures (SPA)	Keegan et al. (1989)
1990	The Customer Value Analysis (CVA)	Customer Value Inc. (2007)
1990	The Performance Measurement Questionnaire (PMQ)	Dixon et al. (1990)
1991	The Results and Determinants Framework (RDF)	Fitzgerald et al. (1991)
1992	The Balanced Scorecard (BSC)	Kaplan and Norton (1992)
1994	The Service-Profit Chain (SPC)	Heskett et al. (1994)
1995	The Return on Quality Approach (ROQ)	Rust et al. (1995)
1996	The Cambridge Performance Measurement Framework (CPMF)	Neely et al. (1996)
1996	The Consistent Performance Measurement System (CPMS)	Flapper et al. (1996)
1997	The Integrated Performance Measurement System (CPMS)	Bititci et al. (1997)
1998	The Comparative Business Scorecard (CBS)	Kanji (1998)
1998	The Integrated Performance Measurement Framework (IPMF)	Medori and Steeple (2000)
1999	The Business Excellence Model (BEM)	EFQM (2007)
2000	They Dynamic Performance Measurement System (DPMS)	Bititci et al. (2000)
2001	The Action-Profit Linkage Model (APL)	Epstein and Westbrook (2001)
2001	The Manufacturing System Design Decomposition (MSDD)	Cochran et al. (2001)
2001	The Performance Prism (PP)	Neely et al. (2001)
2004	The Performance Planning Value Chain (PPVC)	Neely and Jarrar (2004)
2004	The Capability Economic Value of Intangible and Tangible Assets Model (CEVITA ™)	Ratnatunga et al. (2004)
2006	The Performance, Development, Growth Benchmarking System (PDGBS)	St-Pierre and Delisle (2006)
2007	The Unused Capacity Decomposition Framework (UCDF)	Balachandran et al. (2007)

Table 1. A list of performance measurement methods.

Taticchi et al. (2010) analysed the frequency of citations of the performance measurement methods. Only ten of the twenty-five methods were cited more than thirty times. Kaplan and Norton's BSC highlight these results. The works of these authors were cited 168 times (1992), 92 times (1996), 48 times (1993) and 48 times (Kaplan, 1996) (Taticchi, Tonelli & Cagnazzo (2010). Given that this

performance measurement tool received a lot of attention in academic circles (Taticchi, Tonelli & Cagnazzo, 2010; Marr & Schiuma, 2003) and in practice as a management tool (Rigby & Bilodeau, 2011; 2013 and 2015), this dominance is not surprising. According to Rigby and Bilodeau's survey in 2013, thirty-eight per cent of the 1208 organisations they examined used the BSC as a management tool. While this percentage seems to be different every year, this method is constantly in the top twenty-five of adapted management tools (Rigby & Bilodeau, 2013). Moreover, the six most popular management tools of 2012 remained in the top six for 2014, with the BSC as number six (and as the highest performance measurement tool) (Rigby & Bilodeau, 2015). Furthermore, Kaplan and Norton's BSC has received much more attention than the other nine methods that were cited more than thirty times. It has been implemented and tested more often than the others. Besides, more has been written about its application, both positive and negative. Ahn (2001) wrote about the application of the BSC at ABB Industrie AG. This researcher argued the problems with the introduction of the BSC can be divided into those associated with its development and those concerning its use. Concerning its development, it can be said that most of the problems were a result of insufficient recommendations concerning the elaboration of the BSC concept. Furthermore, there was a lack of decision-making aids for companies both when generating and linking the strategic goals and when generating the measures and their values to be attained. The over-complexity caused by the derivation of too many cause-and-effect-chains was another problem, just as the task of defining measures. Finally, the guidelines found in the literature for determining the values for setting milestones and targets for measures were also judged to be insufficient. With regard to its use, the company experienced problems with recording and monitoring the measures. Furthermore, whether the employees would accept the new measures alongside the already existing measures proved to be another problem. Although this and several other studies pointed out limitations of the BSC, some also revealed its usefulness. Hoque (2011), who reviewed 104 articles published in 25 leading accounting journals and 67 articles published in 46 leading management and business journals, argued that the BSC is a triumphant and winning system since its introduction. Hoque (2011) stated that *"the balanced scorecard is a useful, effective performance measurement and strategic management tool in the organisational world"* (Hoque, 2011, p. 20), and that this framework has not lost its relevance in this 21st century, because *"key survival skills for organisations in the modern world are the ability to innovate and their learning capacity, which cannot be captured by conventional financial performance measures"* (Hoque, 2011, p. 21). Altogether, the BSC seems to be a fine method to use.

The BSC is defined as a set of measures that gives top managers a fast but comprehensive view of the business, including both financial and operational measures (Kaplan & Norton, 1992). It is an instrument for the management of organisations to determine strategic objectives and communicate them to the rest of the organisation (Kaplan & Norton, 1996). The BSC uses four perspectives on organisational performance:

- Financial perspective
- Customer perspective
- Internal process perspective
- Learning and growth perspective

The financial perspective is placed at the top of the method. Kaplan and Norton (1996) argued good financials can be seen as the organisation's final objective, as this quote also indicates: *"These perspectives show how employees need certain knowledge, skills, and systems (learning and growth*

perspective) to innovate and build the right strategic capabilities and efficiencies (internal process perspective) so that they can deliver specific value to the market (customer perspective), which will lead to higher shareholder value (financial perspective)" (Kaplan & Norton, 2000, p. 169). The customer-, internal process- and learning and growth perspectives assist in achieving this objective.

The goal of the learning and growth perspective and the customer perspective is to think about respectively a way to sustain the organisation's ability to change and improve, and the organisation's appearance to their customers, in order to achieve the organisation's vision. The goal of the financial perspective is to think about the organisation's appearance to their shareholders, to succeed financially. Kaplan and Norton (1996) argued that to satisfy the organisation's customers and shareholders, the organisation should think about what business processes they should excel at (Kaplan & Norton, 1996). The BSC therefore prescribes that for each perspective, objectives, measures, targets and initiatives have to be determined. Moreover, just after the introduction of the BSC, the authors realised the strategic orientation of the organisation should be the basis from which the KPIs should be derived. Therefore, vision and strategy are placed in the middle of the method, as can be seen in figure 3.

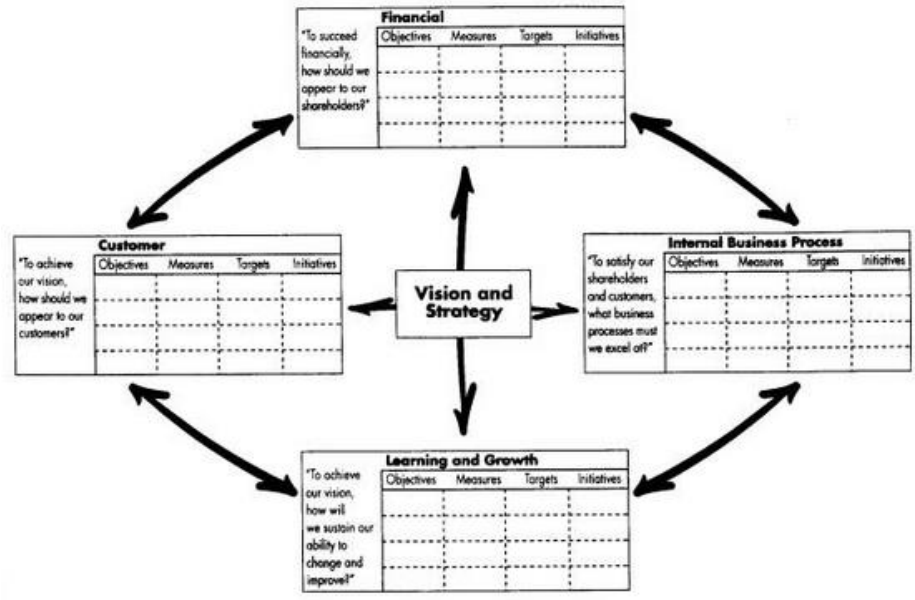

Figure 3. An illustration of the balanced scorecard (derived from Kaplan and Norton, 1996).

2.3. Information waste

Womack, Jones and Roos (1990) were the first authors who addressed the revolution in manufacturing represented by the Toyota production system (TPS). This type of manufacturing system is called a 'lean system'. According to the authors, a lean way of thinking allows companies to *"specify value, line up value-creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively"* (Womack & Jones, 1996, p. 15). Although Womack and Jones (1990; 1996) argue that information management belongs to the three key activities of an organisation, there has been written relatively less about the application of lean thinking to this context. Hicks (2007) is the first author who applied lean thinking to the context of information management. The author argues it is necessary to develop an understanding of waste within the context of information management first. Then, the types of waste present within the management information system and its related processes and activities can be characterised.

Waste within the context of information management is less clear and not generally as visible, and *"can be considered to include the additional actions and any inactivity that arise as a consequence of not providing the information consumer immediate access to an adequate amount of appropriate, accurate and up-to-date information"* (Hicks, 2007, p. 238). In a previous study, Hicks, Culley and McMahon (2006) reported what can be thought of as the barriers to information flow within SMEs. By means of an evaluation of these issues with respect to the concept of information flow, Hicks defined four fundamental causes of waste, which give rise to four corresponding types of waste. The four causes and types of waste can be found in table 2. This table is leading for this research project. This means the author will refer back to this table several times during this report.

Waste category	Cause of waste	Type of waste
Failure demand	Information that cannot flow because it has not been generated, a process is broken, or a critical process is unavailable.	The resources and activities that are necessary to overcome a lack of information. This may include generating new information and/or acquiring additional information.
Flow demand	Information is unable to flow because it cannot be identified and flow activated or shared processes are incompatible.	The time and resources spent trying to identify the information elements that need to flow.
Flow excess	Excessive information is generated and maintained or excessive information flows, and as a consequence, the most appropriate and accurate information cannot be easily identified.	The time and the resources that are necessary to overcome excessive information (e.g. information overload).
Flawed flow	Inaccurate information flows resulting in inappropriate downstream activities, corrective action or verification.	The resources and activities that are necessary to correct or verify information. It also includes the unnecessary or inappropriate activities that result from its use.

Table 2. The categories, fundamental causes and types of waste.

These four categories of waste can be summarised in a cluster table, as table 3 visualises. In short, there is certain information you need and information you get, which can be either correct or incorrect. First of all, if you get correct information but you do not need it, we speak about flow excess. This category of waste can be linked with one of the fifteen items Lee et al. (2002) developed for information quality, namely 'appropriate amount'. Secondly, information you need but do not get because the information is not identified, is defined as flow demand. This category can be linked with Lee et al.'s item 'obtainability'. Flow excess and flow demand deal with information relevance. Failure demand and flawed flow deal with the efficiency of the information process. These categories can be linked with respectively the items 'completeness' and 'free of error'. The other items can be found in appendix A. Information you need but do not get because the information process is not activated, is known as failure demand. Finally, if you need certain information and you get it but it is incorrect, we speak about flawed flow. Useful information, on the other hand, is when you get exactly what you want, and what you get is correct. This can be visualised in a so-called Venn diagram, as figure 4 illustrates. To provide further insight into the four categories of waste, the eighteen barriers to information flow are classified with respect to the categories of waste. These barriers can be found in appendix B. In total, twelve issues can be directly classified with respect to waste, two issues can be partially classified and the remaining four issues relate to the concept of value (Hicks, 2007).

	Do you need this information?	
Do you get this information?	Yes	No
Yes	*Useful information*	*Flow excess* *Flawed flow*
No	*Failure demand* *Flow demand*	*No information waste*

Table 3. The four categories of waste in a cluster table.

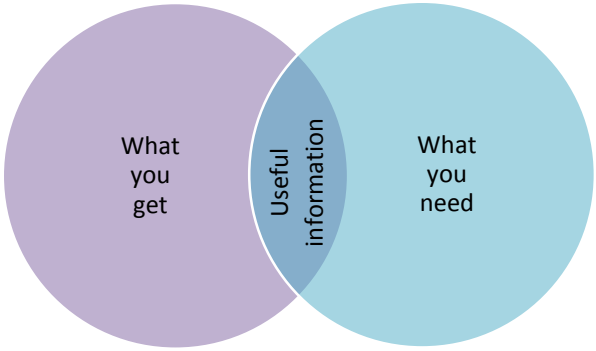

Figure 4. A Venn diagram of the information waste concept.

3. A method for information waste identification

This section describes the method for information waste identification. In fact, the method consists of three phases. In the first phase, the relevance of Company X's current KPIs is assessed. During the second phase, some KPI-related information processes are first modelled after which they are investigated on information waste. The third phase involves designing solutions for the identified information wastes. The method is described phase by phase.

3.1. From CSFs to KPIs

To assess the relevance of Company X's current KPIs, a BSC analysis will be conducted. There are many methods for applying the BSC. Van den Berg (2015) applied the BSC and considered three different methods. The first one was developed by Kaplan and Norton in 1998. The other two are derivatives of this method, the name, act, use and learn-cycle developed by Hudson, Lean and Smart in 2001 and the circular approach developed by Biazzo and Garengo in 2012. According to Hudson et al. (2001) and Biazzo and Garengo (2012), the method of Kaplan and Norton is not suitable for SMEs, mainly because it was developed with large enterprises in mind. Especially Hudson et al. (2001) stated that the main problem with applying this top-down approach in SMEs is that the identification of the CSFs and the KPIs for the various aspects is performed at the same time. These researchers proposed a method defined as incremental to avoid this problem. This method features the sequential repetition of the name, act, use and learn-cycle for every strategic objective, where respectively:

- the main strategic objective to immediately focus upon is identified;
- the performance measures connected with that strategic objective are identified, along with the improvement actions needed;
- the measurement system is implemented and the improvement actions are activated; and
- the target achievement is monitored and, at the same time, the adequacy of the selected measures is assessed.

However, Biazzo and Garengo (2012) argued that this name, act, use and learn-cycle still requires an actual rationalisation of the strategic vision, although Hudson et al. (2001) clearly pointed out that the development processes of performance measurement methods in SMEs should be able to exalt informal strategies and overcome limited experiences and competencies in the formalisation of strategies. Hence, the main difference between their methods is that Biazzo and Garengo's method involves a bottom-up approach. This means their method is able to redesign the current strategy instead of starting from the beginning, for which SMEs generally lack the resources, motivation or capacity (Biazzo & Garengo, 2012). With regard to this research project, the goal of applying a BSC analysis is to determine Company X's strategic orientation in order to assess the relevance of their KPIs. Therefore, the circular approach seems to be the most suitable method in this case.

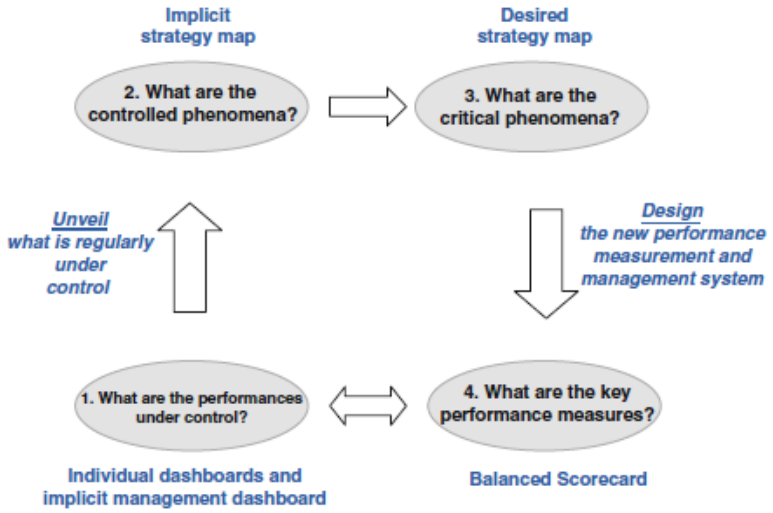

Figure 5. The circular approach (derived from Biazzo & Garengo, 2012).

The circular approach consists of two phases, as you can see in figure 5. In the first phase, it is unveiled what is regularly under control. During the second phase, the new performance measurement and management system is designed. Both phases involve two steps. The output of the first step is an implicit management dashboard, which is the sum of the individual management dashboards. An individual management dashboard is an overview of the KPIs the manager keeps track of. The output of the second step is an implicit strategy map. In both cases it is called implicit because performances are often locally monitored and there is no overall vision of the performances being under control. In other words, it is invisible to the management (Biazzo & Garengo, 2012). The output of the third step is a desired strategy map, also defined as explicit strategy map, whereas the output of the fourth step is a BSC.

By means of conversations with the department managers, the individual management dashboards will be identified. For further analysis of the KPIs, the physical dashboards will be gathered. The individual management dashboards together will form an implicit management dashboard. However, this dashboard does not reflect the company's strategy. It takes an extra step to identify the strategy, in the form of an implicit strategy map. Strategy maps are a way of visualising an organisation's strategy. As you can see in figure 6, the layers of the strategy map correspond with the four perspectives of a BSC. As the figure implies, the underlying layers form the basis for the upper layer. In order to set up an implicit strategy map, it is necessary to carefully examine each KPI and to pair each one with the phenomenon that is measures: The underlying CSF. The various measured CSFs may

be placed in the four perspectives. What emerges is a picture of the CSFs that are currently kept under control and, hence, of the strategy that the company implicitly supports (Biazzo & Garengo, 2012).

Figure 6. A visualisation of a strategy map template.

The implicit strategy map will be reviewed with the department managers. Examples of questions that will be addressed are:

- *"Do the present critical success factors reflect the desired strategic orientation? Or are they not "strategic" at all?*
- *Is there any critical success factor that is not present in the implicit map and should then be added?*
- *Are the critical factors, present in the implicit map and "confirmed" in the desired map, adequately translated by the existing indicators? In other words: do the existing measures actually detect the phenomenon that the organisation wishes to control?"* (Biazzo & Garengo, 2012, p. 31).

The output of this review session will be an explicit strategy map, which really reflects the strategy of Company X. By means of the remaining CSFs, the company's KPIs can be assessed on relevance.

3.2. Information waste detection and solutions to information waste

The focus of this research project is on information processes. BPM tools can help any kind of organisation to analyse and explain its business (information) processes. The analysis of information processes can supply useful and right data for the management of these processes. In short, BPM tools support processes, control flows and provide documents which can be used for the execution of the steps in the information processes (Kashani, 2011). An example of a BPM tool is Bizagi. With this tool, complex information processes can be modelled. Beside its ease of use, it has other advantages like cost saving, reduction or process lifecycle, continuous improvement, governance, control and reduction in operation risk. Additionally, it delivers up-to-date information to managers and employees in order to increase their productivity (Kashani, 2011). In this case, the BPM models are used to detect errors in the delivery process of information, where errors are failure demand (available information that does not flow) and flawed flow (inaccurate information flows). First of all, the involved employees and systems will be identified. Secondly, information about the flow of

information elements will be collected in order to model the information processes. Once the information processes are modelled, it is time to analyse the processes on information waste. Hicks' four types of waste will serve as the framework. The information that is needed will be collected by means of conversations with those involved. Finally, areas of improvement will be determined in order to develop focused improvements. Figure 7 visualises the method for information waste identification.

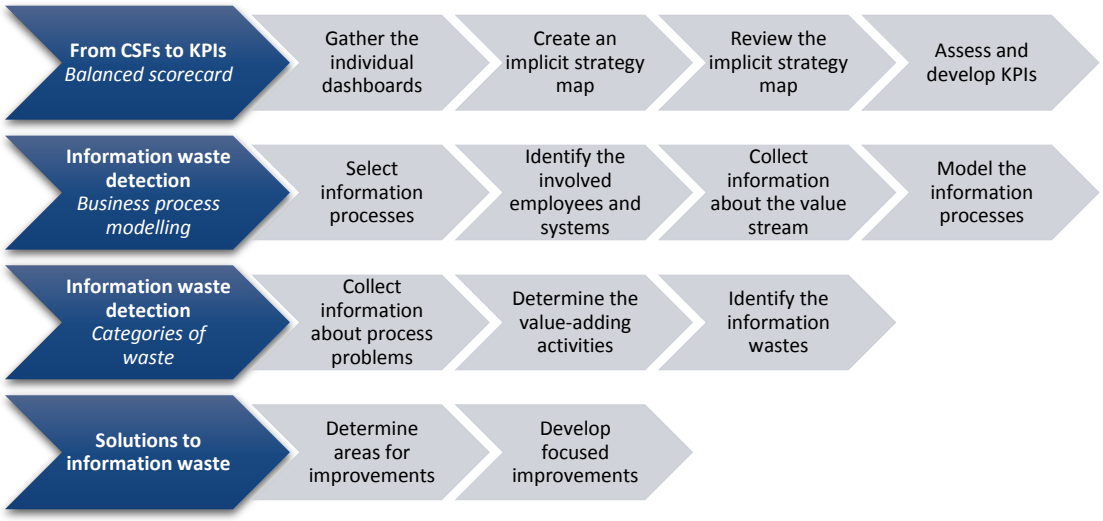

Figure 7. A visualisation of the method for information waste identification.

4. Analysis

4.1. From CSFs to KPIs

This section is structured according to the three phases of the method for information waste identification. As mentioned before, Company X's KPIs will be assessed on relevance first. If the company uses irrelevant KPIs, excessive information flows. It is also possible that Company X does not use relevant KPIs, because the company was unable to identify those. These two scenarios are in line with respectively flow excess and failure demand. The goal is to identify and reduce these information wastes. In section 4.2, the information processes are described and visualised using BPM models. These models are developed with help of those involved in the information processes. Errors in the delivery processes of information (failure demand and flawed flow) are identified and outlined in this section. Solutions to the identified information wastes are proposed in section 4.3.

4.1.1. CSF detection (implicit)

Twenty-four performance indicators were identified. These indicators together form the implicit management dashboard. To go from the implicit management dashboard to the implicit strategy map, the phenomenon that the company desires to keep under control and the accompanying CSF were determined for each performance indicator. This required critical thinking about the reasons behind the indicators. For example, one of the indicators of the department Series Support & Industrial Engineering indicates the progress of the modifications. In the end, the progress depends on the lead time of the modification completion and the quality with which they are handled. Hence, these are the CSFs for modification completion, the phenomenon that the department wants to keep under control. From the twenty-four performance indicators, twenty CSFS were identified. These factors were divided into the four layers of the implicit strategy map, as figure 8 illustrates. The strategy map will be discussed from top to bottom, thus starting with the financial perspective.

Financial perspective

The four CSFs that were placed in the financial perspective are annual leave costs, warranty costs, complaint costs and cost price. Warranty- and complaint costs were derived from the individual management dashboard of the department Quality Management. Both indicators are used to assess the cost of, respectively, the warranties and the complaints. The cost of complaints are divided into customer-, supplier- and internal complaints. Annual leave costs was derived from an overall indicator (not held by one of the departments) that keeps track of the outstanding annual leave days. Too much outstanding annual leave days is disadvantageous, because the company has to pay these hours to the corresponding employees. Finally, cost price was derived from the indicator 'productivity'. Higher productivity can lead to a lower cost price.

Customer perspective

This perspective counts three CSFs: customer requirements, on time delivery and quality. Customer requirements refer to the special sales requests (SSRs). These are the requirements that are not included in the machine standards. The pattern of the SSR volume is comparable with the seasonal pattern of the sales volume. In other words, when the company has to produce more machines, they have to deal with more special sales requests. Satisfying customer requirements can be seen as the marketing strategy of the company. The second factor assesses the on time delivery of the machines. On time delivery expresses reliability to the company's customers. Quality was derived from the indicator 'right first time rate', which indicates the extent of errors with which the machines are produced. By means of this indicator, the company corresponds the quality of the machines to their customers.

Internal process perspective

Ten of the twenty CSFs were placed in the internal process perspective: modification completion, material availability, supplier performance, purchasing performance, level of inventory, capacity utilisation, productivity, distributed workload, on time completion and forecast accuracy. Modification completion refers to the progress of the modifications. Modifications are mostly small adjustments to the existing machines of the company. They are designed to optimise the machines, to have an as good as possible assortment. Material availability was derived from an indicator that indicates the rate of orders released without incompletion. An order is released without incompletion when all the required materials are available before the release date. The performances of the company's suppliers are determined on their reliability. Reliability is measured through subtracting the actual with the requested delivery time. An increase in the on time delivery rate indicates an increase in supplier reliability. Purchasing performance, on the other hand, is based on an indicator that indicates the purchasing price variances. An adverse purchasing price variance indicates higher purchasing costs incurred during the period compared to the standard. Reasons for adverse purchasing price variances include, for example, an overall hike in the market price of materials, an increase in bargaining power of suppliers (both external) or inefficient buying by the procurement staff (internal). The first two examples cannot be easily influenced by an organisation, in contrast to inefficient buying by the organisation's procurement staff. Therefore, purchasing performance is the CSF for purchasing price variances.

Level of inventory was derived from two indicators, gross inventory and days on hand. The department managers of the departments Production Scheduling and Purchasing & Warehousing (one department manager for two departments) are responsible for these indicators. Gross inventory is the sum of raw

materials, semi-finished goods, work in progress, finished goods and test machines. Days on hand is the number of days it takes to sell the company's average balance of inventory. Lower level of inventory will result in lower days on hand. Capacity utilisation was derived from two different indicators: the productivity of the welding robot and the over-/under absorption of the overhead costs. Not so long ago, Company X purchased a welding robot. Today's target is to make more use of the welding robot or in other words, to increase its capacity utilisation. Under absorption means more actual overhead costs were incurred than expected, which is disadvantageous. So, when the actual hours were less than the budgeted hours, this would cause the overheads to be under absorbed. Increasing the capacity utilisation prevents this. Productivity was based on two indicators. The department Production Manufacturing measures the productivity for metal working and surface treatment; the department Production Assembly for assembly and projects. Due to increasing competition, margins get smaller and smaller. Therefore, Company X should try to reduce the cost price. In order to reduce the cost price, the productivity of these two departments should increase. Furthermore, Company X keeps track of the output and backlog of machines. Backlog is the difference between the forecasted and the actual produced machines. An increase in productivity ensures the actual production is as much as the forecasted.

Distributed workload was derived from the indicator 'full time equivalent' (FTE). FTE is the ratio of the total number of paid hours during a period by the number of working hours in that period. It indicates the workload of an employee in such a way that makes workload comparable across various contexts. By means of this indicator, Company X compares the workload of the various departments. The departments Production Scheduling and Production Assembly make use of the indicator 'on time completion'. This indicator measures, as its name already indicates, the on time completion rate of the machines. Obviously, on time completion is vital here. Finally, forecast reliability was derived from the only indicator the department Order Management keeps track of: 'sales overview'. It measures the actual amount of product entries, which is compared with the forecasted amount of product entries. By means of the actual and forecasted amount of product entries, Company X controls their production planning. In this case, the reliability of the forecast is critical.

Learning and growth perspective

The three CSFs that were placed in this perspective are: workplace safety, workforce flexibility and employee satisfaction. Workplace safety is based on the (almost) accident reports of the department Quality Management. These reports assess the amount of and the measures taken against the accidents. Recording accidents is legally required. Besides, Company X deems it important that their employees work in a safe environment. Workforce flexibility was derived from an indicator that assesses the production capacity. As mentioned before, Company X has to deal with a seasonal production pattern. To take control over the production in terms of capacity and occupation, flexible personnel is vital. Finally, employee satisfaction was based on the factor that measures the absenteeism of the workforce. Absenteeism is the not attendance at work, without valid reason. When employees are satisfied, this should be reflected by the absence rate. In other words, the absence rate should be lower when employees are satisfied.

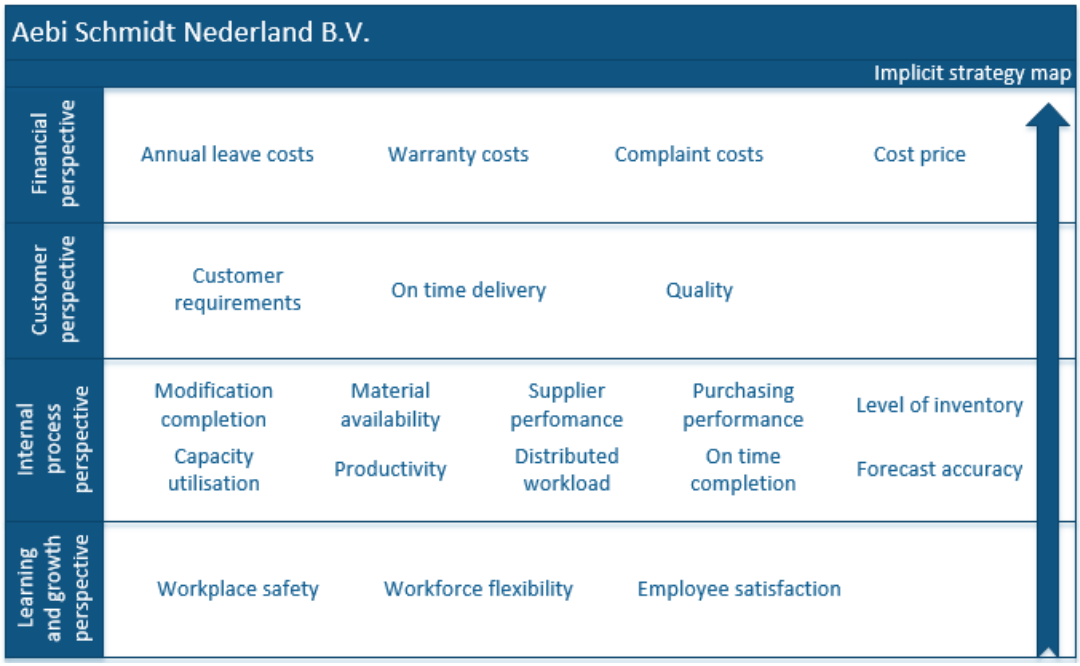

Figure 8. The implicit strategy map.

4.1.2. CSF detection (explicit)

The implicit strategy map is compiled by and based on the author's own interpretation of the performance indicators. The second phase of the Biazzo and Garengo's circular approach starts with reviewing the implicit strategy map in order to create an explicit strategy map. The plan was to discuss the implicit strategy with the involved department managers and the technical director together. However, at the time of this research project, the company had to deal with the high season. Therefore, the implicit strategy map was discussed with the department managers of the departments Production Scheduling, Purchasing & Warehousing and Quality Management only. The strategy map was controlled by the technical director during one of our monthly meetings in which we discussed the progress of the research project. During a conversation with the department manager of the department Quality Management, it became apparent that four of his performance indicators were missing. Apparently he forgot to mention these indicators during our earlier talk. Due to these missing indicators, the total number of performance indicators increased to twenty-eight. Based on the review session with these three department managers and the check by the technical director, the total number of CSFs increased to twenty-four. Table 4 gives an overview of the identified performance indicators and the corresponding critical success factors. Certain CSFs were added to or removed from the strategy map, placed in another perspective or its name changed, as you can see in figure 11. Figure 12 visualises the explicit strategy map.

			Critical success factors																										
		Financial perspective	Sales volume	Level of inventory	Purchasing performance	Product quality	Indirect expenditure	Production costs	Customer perspective	Customer requirements	On time completion	On time delivery	Social return	Quality management system	Environment management system	Internal process perspective	Lead time of modification completion	Quality of the modifications	Material availability	Supplier performance	Capacity utilisation	Social responsibility	Productivity	Forecast accuracy	Annual leave management	Learning and growth perspective	Workplace safety	Workforce flexibility	Employee satisfaction
Performance indicators	Sales overview		X																										
	SSRs									X																			
	Modifications																X	X											
	Gross inventory			X																									
	Days on hand (DOH)			X																									
	On time completion (OTC)										X																		
	Complete order releases																		X										
	Purchasing price variance (PPV)				X																								
	Supplier reliability																			X									
	Productivity metal working and surface treatment																						X						
	Productivity robot																				X								
	Productivity assembly and projects																						X						
	Right first time rate					X																							
	On time delivery (OTD)											X																	
	Cost of warranties					X																							
	Cost of complaints					X																							
	Accidents																									X			
	Social return on investment (SROI)												X																
	ISO 9001 certificate													X															
	ISO 14001 certificate														X														
	ISO 26001																					X							
	Output & Backlog																						X						
	Capacity																							X					
	Over-/under absorption						X																						
	Full time equivalent (FTE)																											X	
	FTE & Absenteeism																												X
	Annual leave																								X				
	Cost saving projects							X																					

Table 4. From implicit management dashboard to implicit strategy map (updated after review sessions).

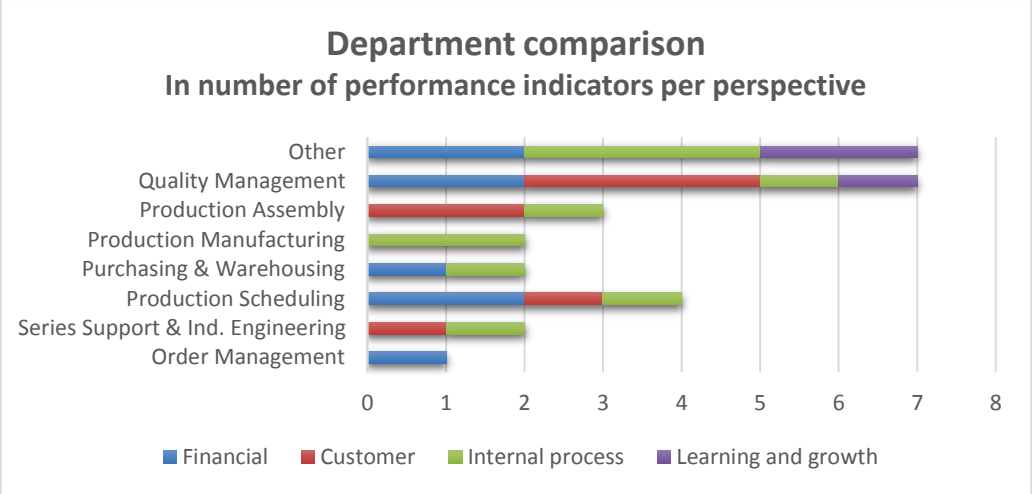

Figure 9. Department comparison in number of performance indicators per perspective.

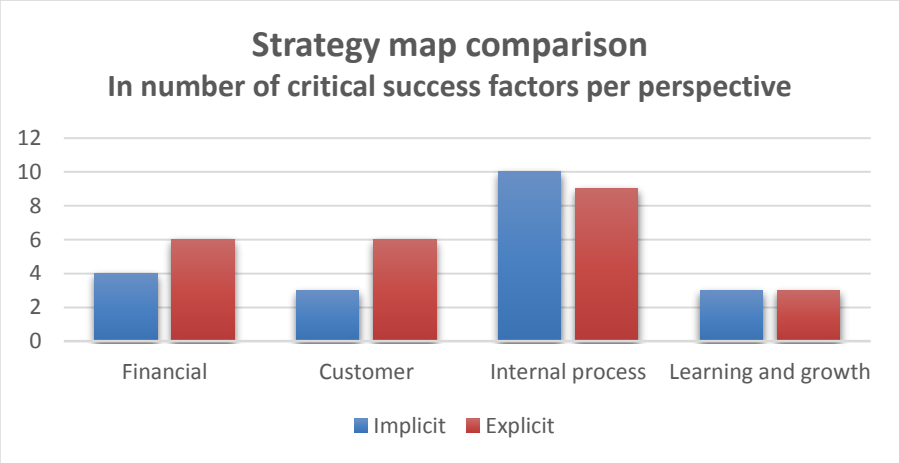

Figure 10. Strategy map comparison in number of critical success factors per perspective.

Financial perspective

Two CSFs were added to the financial perspective: sales volume and indirect expenditure. Indirect expenditure was derived from the indicator that indicates the over-/under absorption of the overhead costs. As clarified before, an increase in capacity utilisation can prevent under absorption. However, indirect expenditure was not taken into account. When the actual expenditures are more than the budgeted expenditure, this causes the overheads to be under absorbed. Sales volume was added to the financial perspective too. As stated before, the performance indicator 'sales overview' indicates the actual amount of product entries. In essence, this indicator is used to control the production planning. In this case, not the reliability of the forecast, but the sales volume is decisive. Purchasing performance and level of inventory were moved from the internal process to the financial perspective. Seventy per cent of the cost price results from the procurement of materials. Hence, there can be saved a lot of money here. For this reason, these two CSFs should be translated into KPIs with financial reasons in mind.

The two CSFs that were merged into one new factor are the warranty- and complaint costs. These costs depend on the quality of the machines that are produced. Therefore, the new CSF is called product quality. Cost price was changed to production costs. As stated before, an increase in productivity can lead to a lower cost price. However, the cost saving projects were not taken into account. By means of reductions in the production costs, the company tries to lower the cost price.

Annual leave costs was moved to the internal process perspective, and its name was changed to annual leave management. Based on the review sessions, it can be concluded that the management of the outstanding annual leave days is more important than the annual leave costs resulting from it.

Customer perspective

Three of the four missing performance indicators of the department Quality Management were placed in the customer perspective. The department manager of this department emphasised the importance of the ISO 9001 (quality), the ISO 14001 (environment) and social return. First two are the international norms for, respectively, quality- and environment management systems. In fact, organisations may not produce without an ISO 9001 certificate. This certificate can be considered as the customer's guarantee for product quality. Quality was already mentioned in the implicit strategy map. However, quality can be achieved by monitoring the company's quality management system. Therefore, the name of this CSF was changed to quality management system. On time completion was moved from the internal process perspective to the customer perspective, because the company can satisfy their customers by completing and delivering the machines on time (on time delivery was already in this perspective).

Furthermore, customers have an increasing demand for eco-friendly products. Therefore, environment management system was added to the customer perspective. The other CSF that was added to this perspective is social return. Social return aims to contribute to increase the employment rate of people with a distance to the labour market. Since the first of July 2011, social return is obliged by the Dutch government as a contractual condition for tenders. Increasing social return activities is therefore of importance. Finally, customer needs was changed to customer requirements. The production time for options and SSRs cover a large part of the entire production time. Therefore, the company should try to maintain this production time at a constant low level. This can be achieved by adopting the most common options and SSRs in the machine standards.

Internal process perspective

Although the number of CSFs has decreased with only one factor, there have been made several adjustments. First of all, modification completion has been split up into two new factors: lead time of modification completion and quality of the modifications. To have an as good as possible assortment, it is necessary to complete the modifications rapidly. However, this should not be at the expense of the quality with which the modifications will be completed. Finally, social responsibility has been added to the perspective. This CSF has been derived from the fourth missing indicator: ISO 26001 (social responsibility). In contrast to ISO 9001 and ISO 14001, ISO 26001 cannot be certified. It provides guidance rather than requirements on how businesses and organisations can operate in a socially responsible way. The company finds it important to pay special attention to social responsible operations.

Learning and growth perspective

Distributed workload was deleted from the internal process perspective. This factor was based on the indicator 'FTE'. However, the actual purpose of this indicator is to assess the size of the workforce, in order to take control over the occupation during the different production seasons (high- and low production season). As stated before, flexible personnel is crucial when the production has a seasonal pattern. This is the only change in the learning and growth perspective.

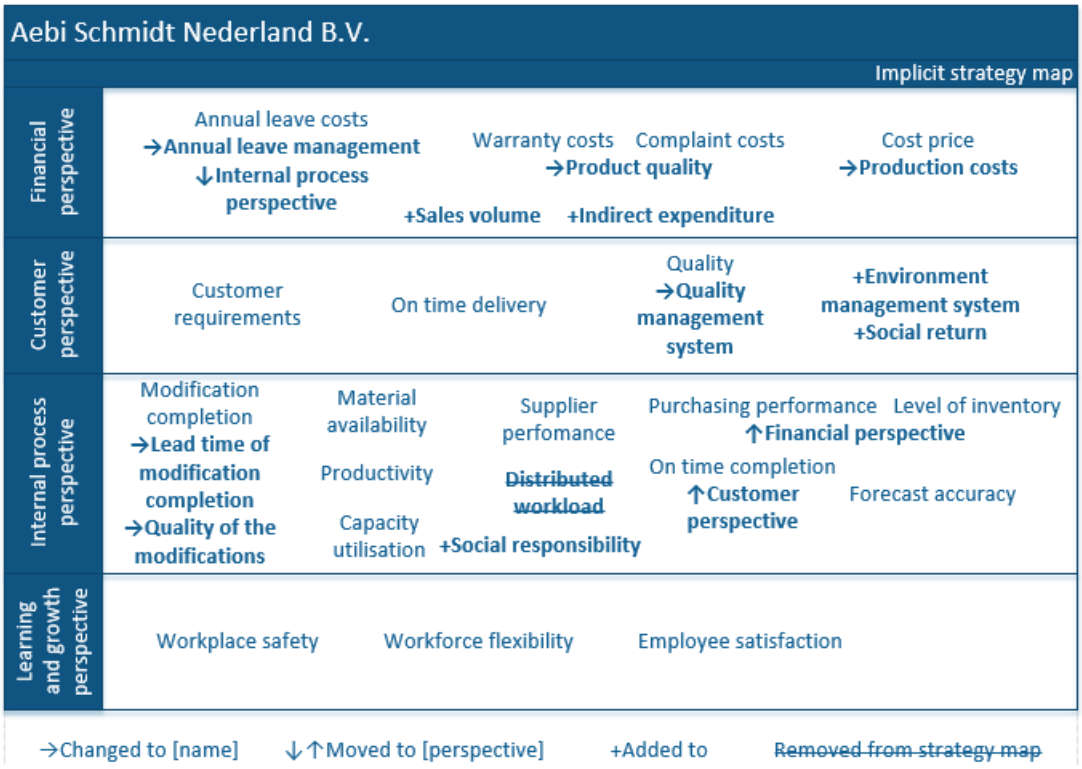

Figure 11. From implicit to explicit strategy map.

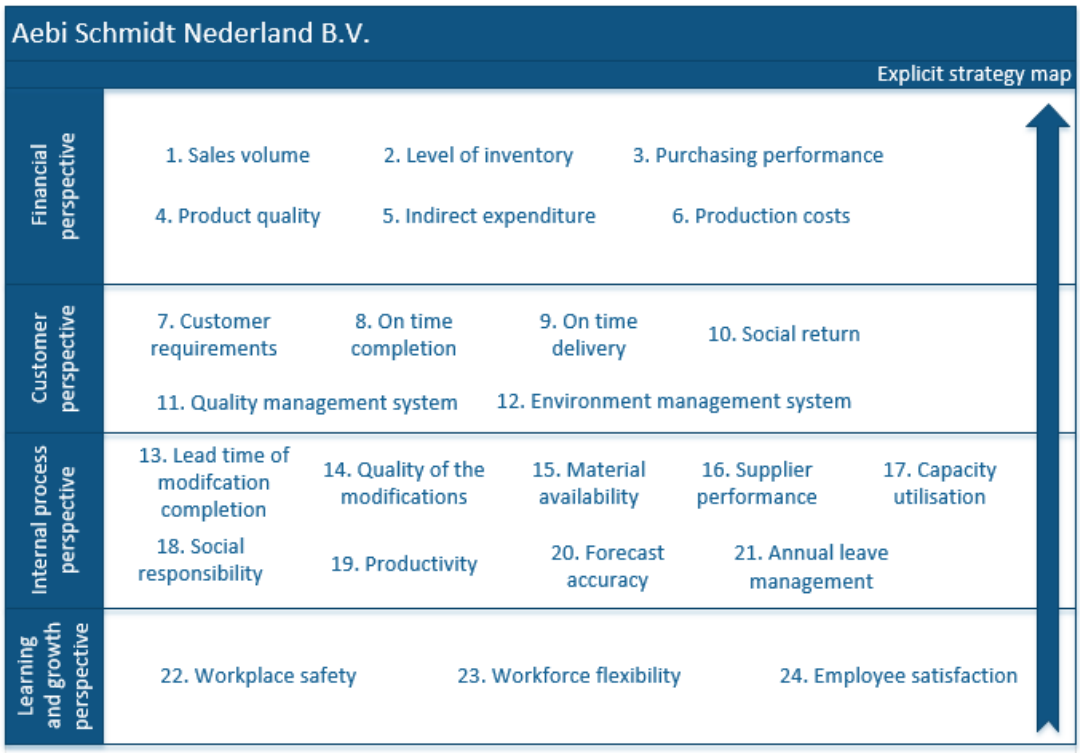

Figure 12. The explicit strategy map.

4.1.3. CSF operationalisation

As figure 13 illustrates, eight of the twenty-nine KPIs are new. These eight KPIs are considered as flow demand. Twenty-one of the twenty-eight earlier identified performance indicators are considered relevant. This means seven performance indicators are considered as flow excess. These are marked red in table 4. If you put these numbers in percentages in the earlier-developed cluster table, you get:

		Do you need this KPI?	
Do you have this KPI?		Yes	No
	Yes	*Relevant: 75%*	*Flow excess: 25%*
	No	*Flow demand: 27.6%*	-

Table 5. The KPI-related categories of waste in a cluster table.

Table 6 gives an overview of both existing and new developed KPIs per perspective. The twenty-nine KPIs cover the twenty-four CSFs that were identified during the previous analyse phase. All KPIs concern either a tactical or an operational level of performance, as you can see in figure 14. Barr's hierarchical subdivision of KPIs was used to divide the KPIs. This last column is added to the table, because the technical director of Company X wanted to know at what level the company is measuring.

Perspective		**Critical success factor**	**Key performance indicator**	**Already in use?**	**Hierarchical level of KPI**
Financial	1	Sales volume	Sales volume variances	Yes	Tactical
	2	Level of inventory	Gross inventory	Yes	Operational
			Days on hand (DOH)	Yes	Operational
			Carrying cost of inventory	No	Operational
	3	Purchasing performance	Purchasing price variances (PPV)	Yes	Operational
	4	Product quality	First time right rate	Yes	Operational
			Warranty- and complaint costs	Yes	Tactical
	5	Indirect expenditure	Over-/under absorption	Yes	Tactical
	6	Production costs	Production costs variances	Yes	Operational
Customer	7	Customer requirements	Extent of customer requirements	No	Tactical
	8	On time completion	On time completion (OTC)	Yes	Tactical
	9	On time delivery	On time delivery (OTD)	Yes	Tactical
	10	Social return	Amount of social return activities	Yes	Tactical
	11	Quality management system	Quality management system	Yes	Tactical
	12	Environment management system	Environment management system	No	Tactical
			Waste consumption	No	Tactical
Internal process	13	Lead time of modification completion	Lead time of modification completion	No	Operational
	14	Quality of modifications	Quality of the modifications	No	Operational
	15	Material availability	Material availability	Yes	Operational

	16	Supplier performance	Supplier performance	Yes	Operational
	17	Capacity utilisation	Capacity utilisation	Yes	Operational
	18	Social responsibility	Social responsibility	No	Tactical
	19	Productivity	Productivity variances	Yes	Operational
	20	Forecast accuracy	Forecast accuracy	No	Tactical
	21	Annual leave management	Annual leave days	Yes	Tactical
Learning and growth	22	Workplace safety	Workplace safety	Yes	Operational
	23	Workforce flexibility	Workforce flexibility	Yes	Tactical
	24	Employee satisfaction	Absence rate	Yes	Tactical
			Job satisfaction	Yes	Tactical

Table 6. An overview of the key performance indicators.

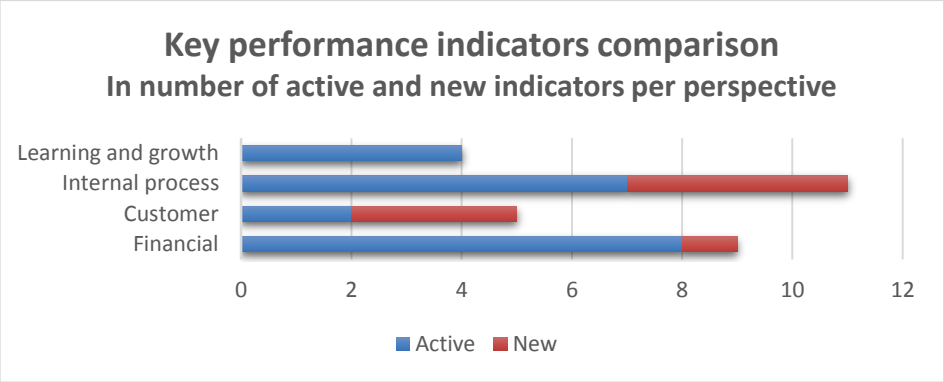

Figure 13. Key performance indicators comparison in number of active and new indicators per perspective.

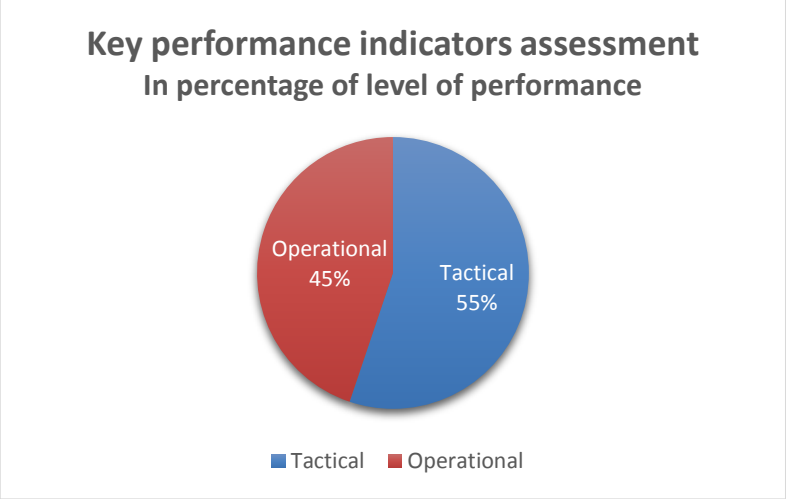

Figure 14. Key performance indicators assessment in percentage of level of performance.

Financial perspective

Sales volume is the CSF for production planning. Company X has several production scenarios. When the sales volume is high, the company produces at a higher production scenario then when the sales volume is low. In this case, sales volume is equal to the sum of the actual product entries. To get full control over the production planning, Company X assesses the amount and development of the sales

volume. The company keeps track of the increase or decrease of the sales volume by comparing the product entries of this period (TP) with the product entries of the previous period (PP).

$$Sales\ volume\ variances = \frac{sales\ volume\ TP - sales\ volume\ PP}{sales\ volume\ PP} \times 100\%$$

$$where\ sales\ volume = \sum actual\ product\ entries$$

Equation 1. The KPI for assessing the sales volume.

Company X calculates its inventory level as the sum of raw materials, semi-finished goods, work in process (WIP), finished goods production and test machines. Because storing and maintaining inventory costs money, the company should try to reduce its level of inventory. Days on hand indicates the amount of time an organisation will hold inventory before the inventory is sold. The outcome of this indicator depends, among the market demand, on the level of inventory. In this case, a low outcome is favourable.

$$Gross\ inventory = \sum raw\ materials + semifinished\ goods + WIP + finished\ goods\ production + test\ machines$$

$$Days\ on\ hand = \left(\frac{average\ inventory\ value}{cost\ of\ goods\ sold}\right) \times number\ of\ days\ in\ a\ period$$

However, less inventory is not always good. At some point, there are no cost benefits anymore. Therefore, it is also important to get insight into the carrying cost of inventory, which can be calculated by multiplying the inventory carrying rate with the average inventory value. The inventory carrying rate is the sum of the inventory costs as a percentage of the average inventory value, and the percentages opportunity costs of capital, insurance and taxes.

$$Carrying\ cost\ of\ inventory = inventory\ carrying\ rate \times average\ inventory\ value$$

$$where\ inventory\ carrying\ rate = 100\% \times \frac{annual\ inventory\ costs}{average\ inventory\ value} + (\%\ opportunity\ costs\ of\ capital + \%\ insurance + \%\ taxes\ )$$

Equation 2. The KPIs for assessing the level of inventory.

Purchasing is tasked with finding materials at the best prices. The better the purchasers perform (acquiring materials at the lowest price), the better your financials, which is also the reason why this indicator was placed at this perspective. Purchasing performance can be found by subtracting the standard prices with the actual purchasing prices, the purchasing price variances can be assessed. A standard price is a pre-established uniform price for a material, based on its historical price, replacement cost, or an analysis of its competitive position in the market.

$$Purchasing\ price\ variances\ (PPV) = \sum purchasing\ prices - \sum standard\ prices$$

Equation 3. The KPI for assessing purchasing performance.

At this moment, product quality is measured by means of the KPI 'first time right'. This indicator indicates the percentage units that are produced right at the first attempt. The underlying idea is that defect prevention is more advantageous and cost effective than defect detection and associated work. The reason why this indicator was placed at the financial perspective is that the quality of the product determines the cost of warranties and complaints. The lower the quality of the products, the higher the warranty- and complaint costs. Therefore, product quality should also be measured in terms of these costs.

$$Right\ first\ time\ rate = \frac{\sum good\ units\ produced\ (direct)}{total\ units\ produced} \times 100\%$$

$$Warranty\ and\ complaint\ costs = \sum cost\ of\ warranties\ (and/or\ complaints)$$

Equation 4. The KPIs for assessing product quality.

Overhead (indirect expenditure) and direct costs equal all the expenses incurred by an organisation. Overhead are those costs required to run an organisation, but which cannot be directly attributed to any specific product. Examples of overhead are administrative salaries, licenses and government fees and utilities. As stated before, the amount of expenses can be, among the capacity utilisation, the cause for over-/under absorption. Therefore, the latter is a good KPI to get insight in the indirect expenditure of the company. Company X uses the following formula:

$$Over-/under\ absorption = production\ variances\ vs.\ BOM\ \&\ routing + purchase\ price\ variances\ incl.\ FX + cost\ center\ absorption\ volume\ driven + cost\ center\ absorption\ remaining + other\ cost\ variances$$

Equation 5. The KPI for assessing indirect expenditure.

Direct costs, also known as production costs, is the sum of the material and the labour costs. An increase or decrease in the production costs can be calculated in the same way as an increase or decrease in the overhead costs. Because the production costs are responsible for a huge part of the cost price, Company X should have these costs under control. By means of this KPI, the company can assess the development of the costs.

$$Production\ costs\ variances = \frac{production\ costs\ TP - production\ costs\ PP}{production\ costs\ PP} \times 100\%$$

$$where\ production\ costs = \sum material\ costs + labour\ costs$$

Equation 6. The KPI for assessing production costs.

Customer perspective

SSRs provide a conflict. On the one hand, Company X desires to fulfil customer needs. However, these customer requirements increase the throughput and cycle time tremendously, which negatively influence the productivity. From a business point of view, the machines should comply with a standard in order to make the production process as efficient as possible. Therefore, the most common options and SSRs should be added to the machine standards. The company can evaluate to what extent the production of a certain machine is customer-specific by assessing the production time of the options and SSRs as a share of the total production time.

$$Extent\ of\ customer\ requirements = \frac{production\ time\ options\ and\ SSRs}{total\ production\ time} \times 100\%$$

Equation 7. The KPI for assessing customer requirements.

On time completion indicates the units that are produced before the confirmed completion date as a percentage of the total units that are produced, which are the units produced before and after the confirmed completion date. On time delivery, on the other hand, indicates the products that are delivered before the confirmed delivery date as a percentage of the total products that are delivered. It is possible that products that are not completed before the confirmed completion date can be delivered before the confirmed delivery date, because Company X includes a buffer of one week in the confirmed delivery date.

$$On\ time\ completion\ (OTC) = \frac{units\ with\ CCD{=}ACD}{units\ with\ CCD{=}ACD + units\ after\ CCD} \times 100\%$$

$$where\ CCD = Confirmed\ Completion\ Date\ and\ ACD = Achieved\ Completion\ Date$$

Equation 8. The KPI for assessing the on time completion (OTC).

$$On\ time\ delivery\ (OTD) = \frac{products\ delivered\ on\ time}{total\ products\ delivered} \times 100\%$$

Equation 9. The KPI for assessing the on time delivery (OTD).

Social return activities is the sum of the total hours spend on social return activities. Social return activities aim to contribute to increase the employment rate of people with a distance to the labour market. The cleaning staff of Company X, for example, consists of people with a distance to the labour market. As stated before, social return is obliged by the Dutch government as a contractual condition for tenders. Therefore, social return is not only good for the image of the company, but also for the entry of products.

$$Amount\ of\ social\ return\ activities = \sum hours\ spend\ on\ social\ return\ activities$$

Equation 10. The KPI for assessing social return.

Maybe more important than the company's perception of quality (first time right), is the ISO 9001. Therefore, it is important to keep this system up-to-date. This can be evaluated by means of the sum of the nonconformities or good practices raised during quality management system audits.

$$Quality\ management\ system = \sum nonconformities\ (or\ good\ practices)\ raised\ during\ audits$$

Equation 11. The KPI for assessing the quality management system.

Another important customer aspect is the environment. ISO 14001 involves guidelines for the certification for the environment management system. In fact, the same KPI as that is used to evaluate the quality management system can be used. However, it is advisable to have some indicators to keep track of the system before it will be audited again (with regard to the quality management system, there KPIs 'product quality' and 'warranty- and complaint costs' indicates the quality of the machines). One of the important aspects of the ISO 14001 is waste consumption, which can be seen as the sum of energy, water and paper consumption. With this KPI, the company can evaluate and, if necessary, plan and implement activities to increase their eco-friendly activities.

$$Environment\ management\ system = \sum nonconformities\ (or\ good\ practices)\ raised\ during\ audits$$

$$Waste\ consumption = \sum energy\ consumption + water\ consumption + paper\ consumption$$

Equation 12. The KPIs for assessing the environment management system.

Internal process perspective

The goal is to complete the modifications as quick as possible and with the highest quality. To assess the speed with which the modifications are completed, the lead time needs to be determined. The lead time of the modification completion can be defined as the modification application minus the modification completion in hours. High quality means no defects will be found in the later stages of the process (for example in the production). In other words, the modification are handled effectively. The effectiveness of modification handling can be defined as the percentage of the modifications closed successful.

$$Lead\ time\ of\ modification\ completion\ (in\ hours) = modification\ application - modification\ completion$$

Equation 13. The KPI for assessing the lead time of modification completion.

$$Quality\ of\ the\ modifications = \frac{\sum modifications\ closed\ successfully}{total\ number\ of\ modifications\ closed} \times 100\%$$

Equation 14. The KPI for assessing the quality of the modifications.

One of the CSFs for on time completion and on time delivery is material availability. Therefore, this phenomenon should be assessed. At this moment, Company X has a KPI that indicates the amount of orders released without incompletion as a percentage of the total number of orders released. The more (right) materials are available, the higher the amount of orders released without incompletion. This improves the on time completion and on time delivery of the machines.

$$Material\ availability = \frac{\sum orders\ released\ without\ incompletion}{total\ number\ of\ orders\ released} \times 100\%$$

Equation 15. The KPI for assessing material availability.

The performance of the suppliers is monitored through the on time delivery of the materials. This is important, because their performances have influence on the on time completion of the machines. The percentage on time delivery of the suppliers can be easily calculated by dividing the sum of the on time deliveries divided by the total number of deliveries. By means of this indicator, Company X can take action when certain suppliers do not meet the desired on time delivery rate.

$$Supplier\ performance = \frac{\sum on\ time\ deliveries}{total\ number\ of\ deliveries} \times 100\%$$

Equation 16. The KPI for assessing supplier performance..

Next to indirect expenditure, capacity utilisation affects the amount of over-/under absorption. To positively affect this phenomenon, Company X should try to increase its capacity utilisation. For this reason, it is important to keep track of this phenomenon. Capacity utilisation is the difference between the actual and potential output, divided by the potential output.

$$Capacity\ utilisation = \frac{actual\ output - potential\ output}{potential\ output} \times 100\%$$

Equation 17. The KPI for assessing capacity utilisation.

Social responsibility is one of the phenomena that was identified during the review sessions. Together we agreed this phenomenon should be assessed from the internal point of view, thus from the company's operations (internal process perspective). Company X can distribute surveys to their employees in order to figure out how they see the company with regard to social responsibility.

$$Social\ responsibility = \frac{\sum employees\ who\ consider\ the\ company\ as\ social\ responsible}{total\ number\ of\ employees\ who\ filled\ out\ the\ survey} \times 100\%$$

Equation 18. The KPI for assessing social responsibility.

Productivity is one of the main KPIs for a production company. Productivity should increase to ensure machines are produced and delivered on time. Furthermore, an increase in productivity can lead to a decrease in the cost price. Productivity can be calculated through dividing the sum of the production hours with the direct presence hours. Direct presence hours can be defined as the hours which are actually spend on the production of the machine. Company X can keep track of changes in the productivity with the following formula:

$$Productivity\ variances = \frac{productivity\ TP - productivity\ PP}{productivty\ PP} \times 100\%$$

$$where\ productivity = \frac{\sum production\ hours}{\sum attendance\ hours\ (direct)} \times 100\%$$

Equation 19. The KPI for assessing productivity.

Company X's production planning is partially based on a rolling forecast. Therefore, a reliable forecast is very important. A forecast is reliable when it accurately indicates the sales volume (sum of the product entries). Forecast accuracy can be calculated by dividing the forecasted sales volume with the actual sales volume.

$$Forecast\ accuracy = \frac{forecasted\ sales\ volume}{actual\ sales\ volume} \times 100\%$$

Equation 20. The KPI for assessing forecast accuracy.

To make sure employees do not take a leave during the high season, Company X can motivate them to take a leave when the company is less busy. The performance of the Company X's annual leave management can be evaluated by the percentage annual leave days exhausted in terms of total days entitled. When a pre-determined goal is not reached, the company can decide to take action.

$$Annual\ leave\ days = \frac{\sum days\ exhausted}{total\ days\ entitled} \times 100\%$$

Equation 21. The KPI for assessing annual leave management.

Learning and growth perspective

The Occupational Safety and Health Administration (OSHA) requires certain organisations to report their statistics concerning accidents, injuries and other incidents that occur while on the job. OSHA requires the accident rate to be expressed as incidents per 100 employees with maximum straight hours. The 200.000 in the formula represents how many hours would be worked by 100 employees (40 hours per week, 50 weeks per year). Company X keeps track of accidents and incidents, however not with such a formula.

$$Workplace\ safety = \frac{total\ accidents\ and\ incidents \times 200.000}{total\ hours\ worked} \times 100\%$$

Equation 22. The KPI for assessing workplace safety.

Because Company X has to deal with a seasonal production pattern, it is of great importance to keep track of the composition of the company's workforce. Company X has to make sure it can manage the production peak during the high season through attracting temporary employees. The company should monitor the portion of limited and temporary employees in relation to the total number of machines to evaluate their performance with regard to workforce management.

$$Workforce\ flexibility = \frac{\sum limited\ and\ temporary\ employees}{total\ numer\ of\ machines\ produced} \times 100\%$$

Equation 23. The KPI for assessing workforce flexibility.

Absence rate and job satisfaction should cover the phenomenon employee satisfaction. The less employees are absent, the more satisfied they are. As stated before, not everyone agrees with this thought. Therefore, Company X should check this by means of surveys. Furthermore, employees can express their satisfaction or dissatisfaction during performance appraisals. This is however not a KPI in itself.

$$Absence\ rate = \frac{\sum working\ days\ lost}{(total\ number\ of\ employees \times total\ number\ of\ working\ days)} \times 100\%$$

$$Job\ satisfaction = \frac{\sum employees\ with\ high\ job\ satisfaction}{total\ number\ of\ employees} \times 100\%$$

Equation 24. The KPI for assessing employee satisfaction.

4.2. Information waste detection

Due to time constraints, not all KPI-related information processes can be reviewed on information waste. Because this research project aims to identify solutions for the problems most detrimental to the performance of Company X, the information processes of the most important KPIs are reviewed. The KPIs that are reported to the division can be considered most important, since the holding evaluates the division's performance on these ones. The KPIs that are reported are included in the operational performance meeting (OPM) sheets. The technical director of Company X presents these sheets to the division every month. The division reports the sheets to the holding. Twelve of the twenty-nine KPIs are included in the OPM sheets. These are sales volume, gross inventory, days on hand, right first time rate, warranty- and complaint costs, on time completion, over-/under absorption, production costs, capacity utilisation, productivity, annual leave days and absence rate. To be clear, the holding decided that the production sites have to report these indicators to the division. Because it is still too much work to review twelve information processes, the second criterion is doubtfulness. Doubtfulness refers to any doubts about information waste. In the previous section, examples of flow demand were identified. However, it is also possible that unnecessary or incorrect information flows (flow excess and flawed flow, respectively) or that existing information elements does not flow (failure demand). After both a quick scan and some intuition, the following most important and doubtful KPIs are selected:

- Gross inventory
- Days on hand
- Warranty- and complaint costs
- On time completion
- Capacity utilisation
- Productivity

Central to this research project and especially this section are the four categories of information waste. In short, there is information you want and information you get. When you do not get information that you want, we speak about failure demand or flow demand. When certain information processes are not activated, we talk about failure demand. When there is not an information process at all, because certain information is not identified (yet), we talk about flow demand. When you get information that you do not want, we speak about flow excess or flawed flow. Flow excess refers to the information that you do not want at all. Flawed flow is incorrect information. Nobody wants incorrect information.

Gross inventory and days on hand

All these information processes ones started at the holding. Somewhere in the past, the holding decided that every division has to report certain performance measures every month. The technical director of each production site has to present these measures to the division. At Company X, the controller generates the KPIs for the technical director.

The information process of gross inventory is not very exciting. As described before, the inventory level is the sum of raw materials, semi-finished goods, WIP, finished goods productions and test machines. The only thing the controller has to do is collecting this information from SAP. The amount of each variable depends on daily transactions like purchasing and consuming materials. Once per month, the controller has to prepare the OPM sheets for the technical director, who has to present them to the division, as you can see in figure 15. The information process of days on hand is actually the same as that of gross inventory. To calculate this indicator, the level of inventory is required. Days on hand is calculated by means of a formula which is determined by the holding.

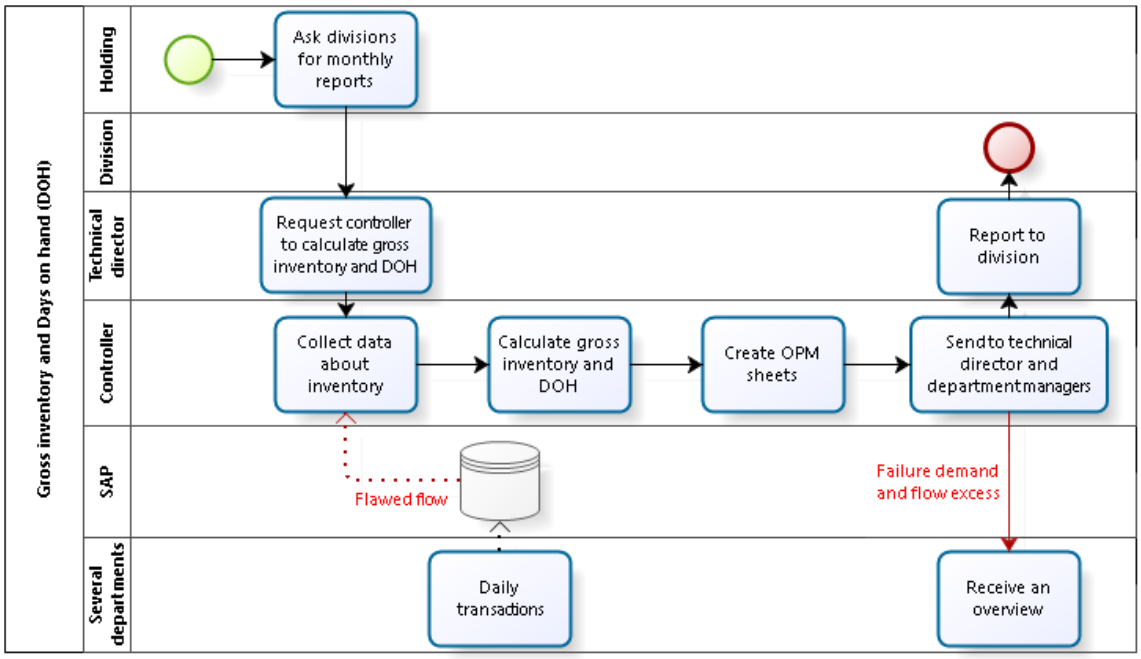

Figure 15. The information process of the KPIs 'gross inventory' and 'days on hand'.

Surprisingly, these KPIs are neither used by the department manager of the department Production Scheduling nor the department manager of the department Purchasing & Warehousing. The department manager of the first-mentioned department argues that she does not make use of the overviews that are generated by the controller, because they contain too less information to make focused decisions. Besides, she is not familiar with the formula. To be more precise, she does not know what the underlying sources of the information are. The information is pulled out from SAP, however it is not known where this information comes from. Maybe this is caused by the fact that the formula is determined by the holding. The only thing the controller has to do is to put the right numbers in the sheet. Moreover, the Logistic Monitoring System (LMS), which is a system that is incorporated in SAP, indicates very different outcomes than those of the controller. Because the formula and the underlying sources of these figures are known, the outcomes are automatically more reliable than the other ones. However, the problem here is that this cannot be verified, because the formula and underlying sources of the figures of the controller are not known.

In fact, three of the four categories of waste are present here. First of all, the department managers obtain too less information to make focused decisions (failure demand). Furthermore, the information they get is probably not correct and should be corrected or verified before the department managers could (if they even want to) use them. Besides, unnecessary or inappropriate activities can result from its use. These are typical examples of flawed flow. Thirdly, in order to verify the obtained information,

the department manager of the department Production Scheduling has asked the controller several times where the figures come from. As a response, she got a lot of information concerning sheets with formulas which she did not understand and therefore could not use (flow excess).

Warranty- and complaint costs

Most of the time, complaints result in warranty costs. However, there are also examples which prove the opposite. If, for example, the complaint is outside the terms of warranty but the problem is structural, Company X can decide to let the concerned product send to Holten and investigate it. This goes along with costs, complaint costs. Another example are modifications that have to be designed due to structural problems caused by the actual design. These modifications have to be designed and tested before they will be implemented, which also goes along with costs. Nevertheless, as can be seen in figure 16, the processes can be modelled in the same template.

All the available information with regard to warranty- and complaint costs is included in the Q-Module, an own-developed module that is incorporated in SAP. Overviews of what has been claimed and what has been paid are present in the QS-Cockpit. This file is created by a colleague from Germany and can be used by each of the four production sites. The file contains information from SAP which is entered by the different sites. The department manager of the department Quality Management and the department manager of the department After-Sales (located at the LSO in Holten) are responsible for the figures of Company X. The controller only copy pastes the overviews in the OPM sheets. Nevertheless, when the customer has a complaint, it will call the local sales organisation (LSO). If the complaint concerns a machine failure, the LSO will send a mechanic. If possible, the mechanic repairs the machine and reports the complaints and undertaken actions to the service manager of the LSO. All the costs evolved from the complaint will be charged to the concerned production site. This also includes the costs that goes along with sending a mechanic, which are sometimes much higher than the actual repair costs. After each month, the production sites receive invoices from the LSOs. Invoices lower than €500,- have to be paid immediately, except if they do not meet the warranty terms. Invoices equal to and higher than €500,- will be examined by Company X. If the company does not agree with the claim at all, they can refuse to pay it. This actually never occurs. Most of the time, Company X pays a part of the claimed warranty costs. This means the other part has to be paid by the LSO itself.

There are two types of information waste present in the information process of warranty- and complaint costs: failure demand and flawed flow. As stated before, the invoices above €500,- are investigated by Company X. Either the department manager of the department Quality Management or the department After-Sales checks the causes of the costs in the Q-Module. During a conversation with the first-mentioned manager, it immediately became apparent that most of the time the information about the causes present in the Q-Module are not sufficient enough. The description of the problem does not always say what has happened. To find out what has happened, the department managers have to call with either the service manager of the LSO or the mechanic who has actually repaired the machine. This is a classic example of failure demand. The department managers do not get the information they wish to have. They have to undertake actions in order to acquire additional information. Secondly, the information that the department managers do get, need to be corrected sometimes. The descriptions of the problems are entered by the mechanic. When the mechanics do not master the English language, the complaints are described in their native language (which the department managers do not master). This information has to be translated first, before the

department managers can use it. Furthermore, sometimes mechanics enter a different designation for a certain component. This information is not wrong in itself, but has to be corrected into the designation the company uses. These are examples of flawed flow. Additional activities have to be undertaken to correct or verify the information.

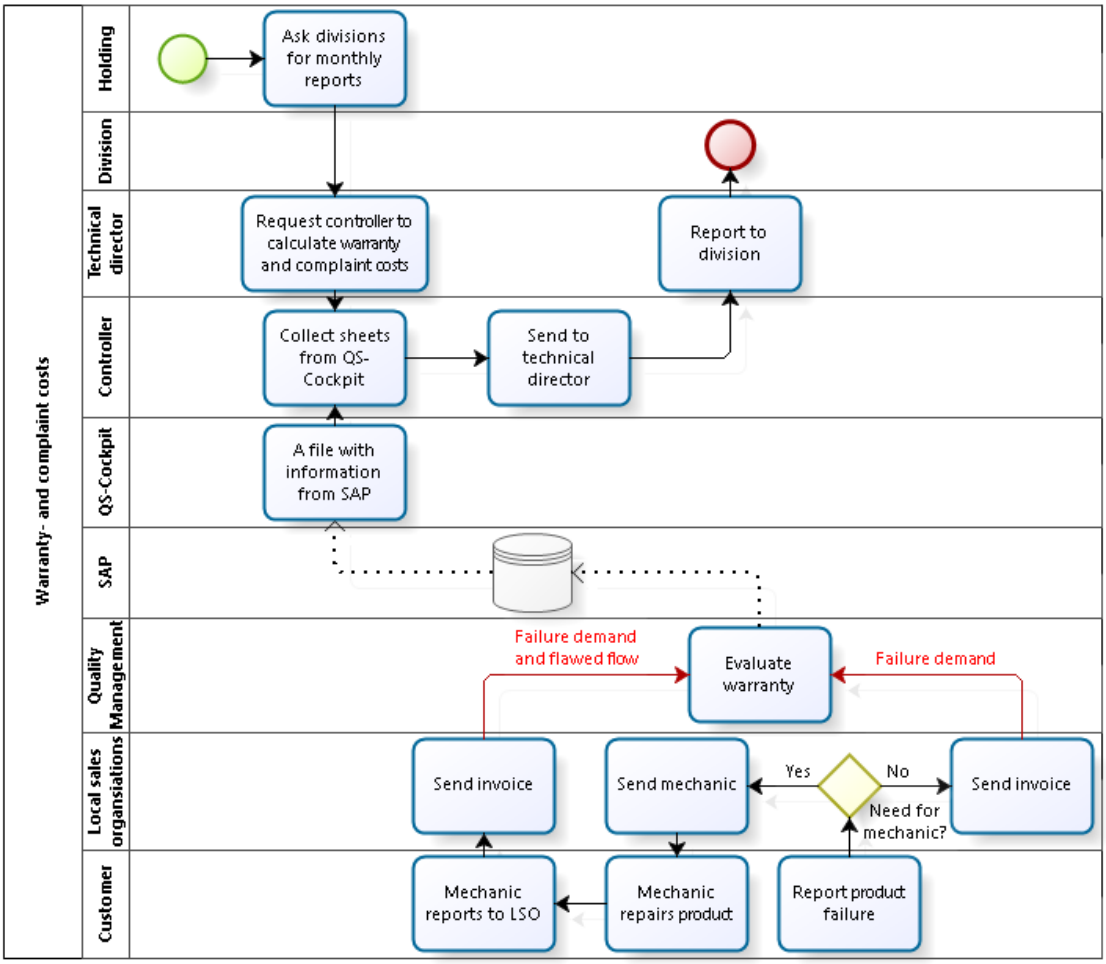

Figure 16. The information process of the KPI 'warranty- and complaint costs'.

On time completion

To calculate on time completion, the controller has to collect the planned and the completed number of products for a certain week. He can collect this data from SAP. The production planning is submitted there by the department Order Management, the number of completed machines by the department Production Assembly. If all goes well, the number of products that are planned for production are completed at the end of the week. However, sometimes products cannot be finished because certain materials that are purchased are not delivered yet, or machines are disapproved because they do not meet the quality standards. If this is the case, the on time completion for that week is not one-hundred per cent.

When there are certain particularities, the department manager of Production Scheduling will let the controller know. An example of such a particularity is the rescheduling of the production of a certain product. Products can be rescheduled because the customer has changed his mind and wants, for example, one or two more options. Then the confirmed completion date will be moved to a later date. Because the controller cannot see this anywhere, the department manager of the department Production Scheduling will let him know. In this way, Company X prevents themselves for incorrect

calculation of on time completion. After the controller has calculated on time completion, he will send it to the department manager of the department Production Scheduling, who checks if the figures are correct. Feedback is send back to the controller, who will correct certain calculation errors (if there are any) and create the OPM sheets. Again, these sheets are send to the technical director and the department managers. The technical director will report the outcomes to the division.

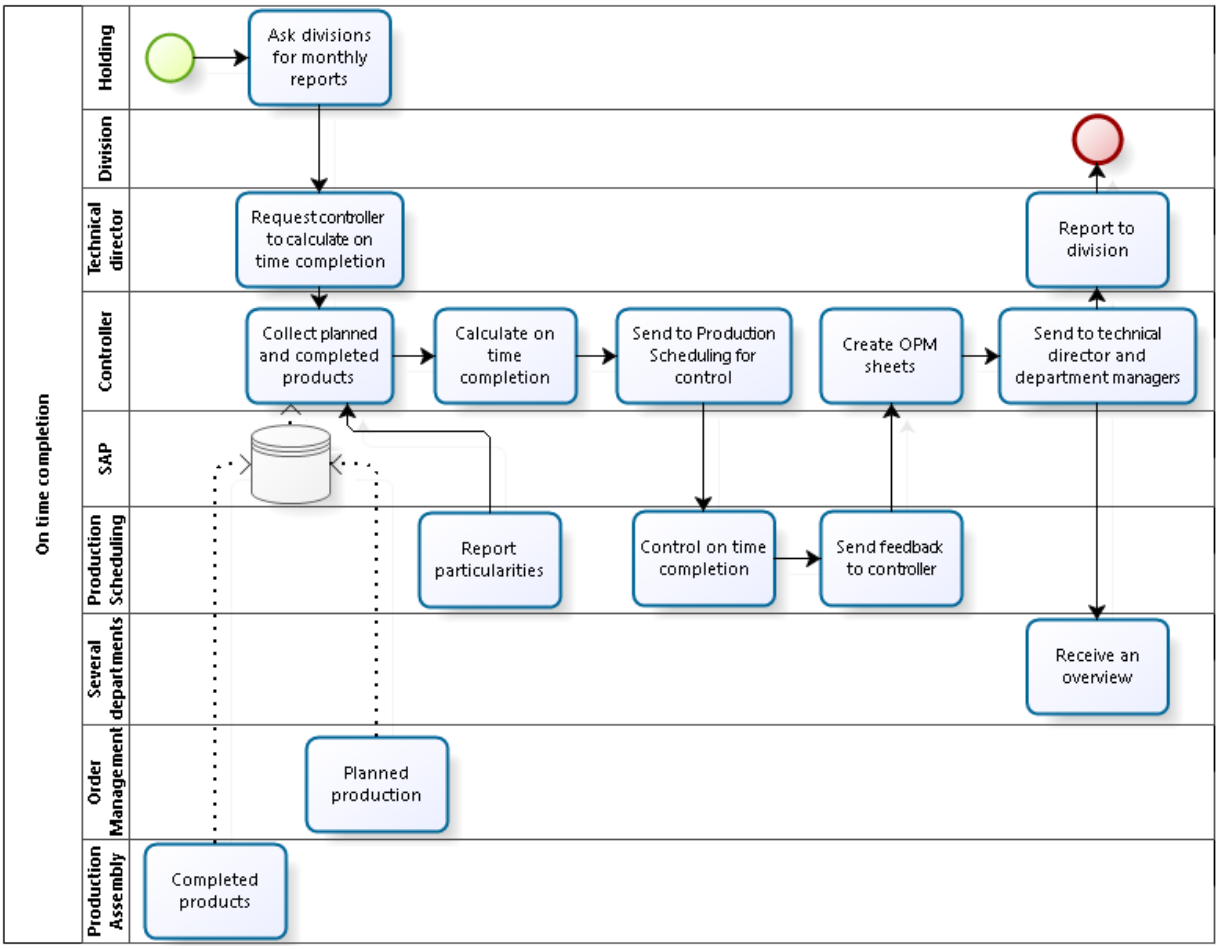

Figure 17. The information process of the KPI 'on time completion'.

Sometimes the controller forgets to take into account the particularities reported by the department manager of the department Production Scheduling. However, if you compare this information process with the other ones, you can see one important difference. There is an extra control embedded in this process. Before the controller includes the on time completion overview in the OPM sheets, they are controlled by the department manager of the department Production Scheduling. She checks if the controller has taken into account the particularities she had reported, for example that the production departments were closed for one day. In this way, they prevent that incorrect information is included in the OPM sheet and ultimately reported to the holding. By means of this extra check which is embedded in the process for almost a year now, the flawed flow of information which was present in this information process is gone.

Furthermore, the controller sends the numbers of the products that are not completed before the determined completion date to the department manager of the department Production Scheduling, so she can check if it is correct that these machines are not finished yet (and why not). In the beginning, the department manager only received the final overview. However, then she did not know which

machines were not finished yet. She has reported this to the controller, and they agreed he will send her the numbers of the concerned machines. In this way, they solved the problem of her not having enough information (failure demand).

Capacity utilisation

Capacity utilisation is the difference between the actual and the potential output in production hours. The potential output is based on the rolling forecast, which is derived from the annual production plan. Both forecasts are made by a select group of employees of Company X, of which the technical director is responsible. Eventually, he is responsible for these forecasts. The annual production plan is made at the beginning of each year. This forecast is mainly based on historical sales volumes and predictions about the upcoming year (market growth, economic situation, etc.). The rolling forecast, on the other hand, changes continuously. First of all, because of the fluctuating demand. Secondly, because LSOs can cancel previously arranged deals. Nevertheless, this select group of employees determines the potential output in production hours for each month. These hours are compared with the backflush hours, the actual output. Backflush hours are predetermined production times. Every machine and option has a predetermined production time. These production times are determined by a select group of people working at the department Series Support and Industrial Engineering (defined as drawing office in the diagram) with sufficient knowledge and experience to estimate them accurately. The predetermined production times are stored in SOFON. When an order is released, they will be available in SAP. The controller can collect the concerned backflush hours from SAP. When the corporate controller has collected both hours, he can calculate the capacity utilisation.

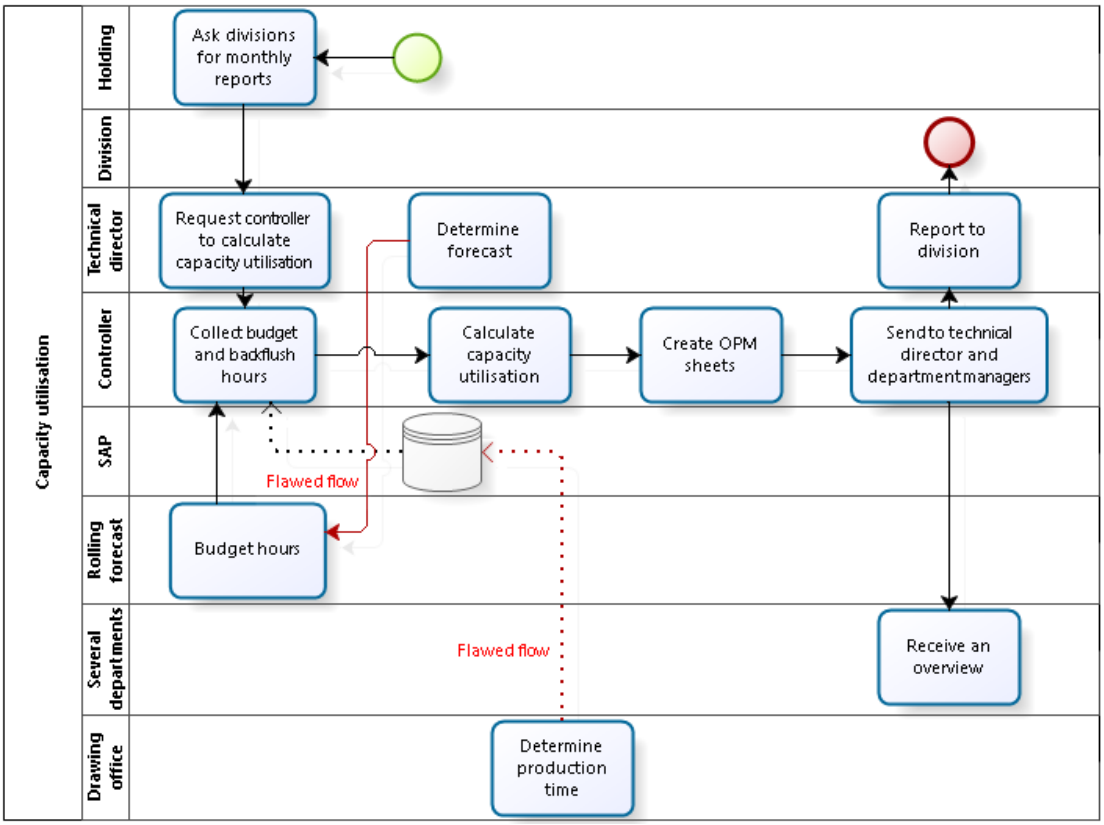

Figure 18. The information process of the KPI 'capacity utilisation'.

As you can see in figure 18, the backflush hours are determined by Series Support & Industrial Engineering (defined as 'Drawing office' in the figure for practical reasons). Hence, their knowledge

and experience is decisive for the determination of the backflush hours. It does not matter how skilled or experienced you are, you cannot exactly estimate what the production time of a certain option or even a whole machine is. By the way, this will be even harder when the component or the machine is not produced before, like the airport projects the organisation has to deal with. This means inaccurate information flows, resulting in an incorrect outcome of the indicator and probably inappropriate actions in the downstream activities (flawed flow). This is confirmed by several department managers, who have indicated that time has shown that these forecasts do not match at all with the reality. The same applies for the budget hours, which are based on a forecast. Just like you cannot exactly estimate what the production time of a certain component is, you cannot exactly estimate how many product your customer demand at a certain period in time. However, you can improve the accurateness of a forecast (O'Connor, Remus & Griggs, 2000). Beside this flawed flow, there are no other types of information waste identified in this information process.

Productivity

For management purposes, productivity is calculated per week. To calculate this KPI, the controller needs the direct attendance and backflush hours (explained in the previous section). As mentioned earlier in this report, attendance hours are divided into indirect and direct attendance hours. The attendance hours of the employees working at departments like Order Management, Production Planning and Purchasing are indirect. These hours do not directly contribute to the production of the product. Logically, the attendance hours of the employees working at Production Manufacturing and Production Assembly are initially direct attendance hours. These employees contribute directly to the production of the product. Nevertheless, these hours can be divided into P0- and P1-hours, where P0 are the hours which are really spend on the production of the product. P1-hours are the attendance hours which are spend on staff meetings, etc. These do not directly contribute to the production of the product. The corporate controller receives the P0-hours from the payroll administrator (HRM department). This employee can collect these hours from SAP. Because every employee has a badge with which they have to clock in and out every day, the attendance hours will be automatically administrated in SAP. If there are any changes in cost centres (a production employee is going to work for the department Product Development for a month, which indirectly contributes to the production of the product and therefore involve P1-hours), the department manager of the department Production Assembly will let the department HRM know. Smaller changes in cost centres are handled by means of clocking in and out on the concerned department. When the controller has collected the P0- and the backflush hours, he can calculate the productivity of the technical organisation. The outcome of this indicator is send to the involved department managers every week.

First of all, the controller calculates this KPI and sends the outcome to at least the production department managers every week. The department manager of the department Production Assembly uses this weekly update for his dashboard, an overview of the performances of his department to inform his employees. However, when the controller is, for whatsoever, not present at work, nobody takes over this responsibility. In other words, then the outcome is not send to the department managers; the process is not activated. Moreover, when the controller is back, he does not send the outcome of the missing week anymore. He just includes that week in his overview, which indicates the productivity per month. However, the dashboard of the department manager indicates the productivity per week. This means he has to undertake an additional action (approaching and asking the corporate controller) in order to acquire the outcome of the missing week separately. These are two examples of failure demand.

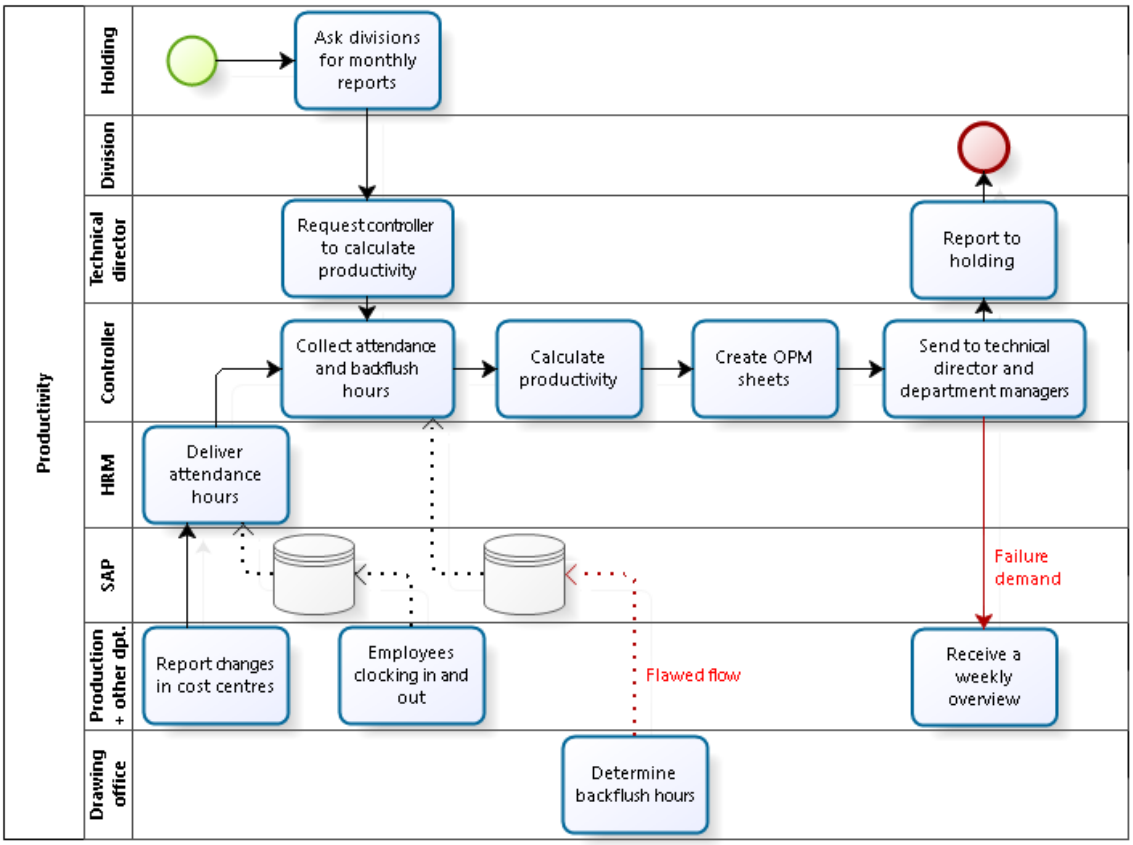

Figure 19. The information process of the KPI 'productivity'.

The problem with the backflush hours are already described in the previous section. Also the attendance hours are not always correct. A few weeks ago, the department manager of the department Production Assembly went on vacation. Normally, he and the payroll administrator speak each other at the end of the week to discuss any changes in cost centres. However, when the department manager came back, these changes were not reported correctly to the administrator (flawed flow). This means the attendance hours of several employees were reported as P0-hours, despite the fact they had not done any work that directly contribute to the production of the machines. This has of course a negative impact on the outcome of the indicator, which was decreased to thirty-six percent. Because the outcome was already calculated and (without anyone even checking) reported to the division, the outcome could not be corrected anymore. By means of an accounting trick the figures were rectified in the weeks thereafter, which is of course detrimental for the reliability of them.

4.3. Solutions to information waste

The purpose of this section is to propose focused, practical improvements on the problems that were identified before. The following table summarises the problems.

Process	Problem
Gross inventory and days on hand	Failure demand: Department managers obtain too less information to make focused decisions.
	Flawed flow: Probably incorrect information which cannot be verified because the basis sources are unknown.
	Flow excess: Controller sends too much (irrelevant) information when department manager asks for something.

Warranty- and complaint costs	Failure demand: Incomplete problem descriptions.
	Flawed flow: Information in different languages and use of different designations by the mechanic.
On time completion	Flawed flow: Controller did not take into account reported particularities.
	Failure demand: Department manager did not get information about the machines which are not finished before the confirmed completion date .
Capacity utilisation	Flawed flow: Forecasts do not match with the reality.
Productivity	Failure demand: Weekly overview is not send to the department manager when controller is absent and missing week is not send the week thereafter.
	Flawed flow: Changes in cost centres are not always reported correctly to HRM (when department manager is absent).

Table 7. A summary of the information wastes that were identified.

As is mentioned in the previous section, the problems in the on time completion information process are already solved by the company. Therefore, this section focuses on the problems in the information processes for generating gross inventory and days on hand, warranty- and complaint costs, capacity utilisation and productivity.

Gross inventory and days on hand

The main problem with both gross inventory and days on hand is that neither the controller nor the department managers of the departments Production Scheduling and Purchasing & Warehousing do not exactly know how the calculation process is build. In other words, they do not precisely know what information is used and where this information comes from. This is caused by the fact that the formula is not developed internally, but imposed by the holding. The only thing the corporate controller has to do is to pull out information from SAP and put it in the formula. As a consequence, the correctness of the information cannot be verified. Furthermore, since the Logistic Monitoring System (of which the sources are known) indicates different outcomes, the department managers cannot rely on the information that is supplied by the controller. During several conversations with the involved department managers, it became apparent that the formula is developed by a manager of another production site. A very practical solution to this problem is to contact this manager and ask him to explain the formula and to declare the underlying sources. Once this is clear, a team of financial and information professionals can assess the correctness of the information and the information process. In this way, the company makes sure good quality information flows. Furthermore, the organisation should determine which information should flow according to the needs of the information consumers. Bevilacqua, Ciarapica and Paciarotti (2015) state that *"lean principles and tools may not be easy to understand and apply for non-experts. For this reason, lean information management implementation needs a lean expert that can easily coordinate and direct the efforts towards a lean direction"* (Bevilacqua, Ciarapcia & Paciarotti, 2015, p. 765). This means that if the company decides to implement lean information management, they should hire lean experts. However, once the process is coordinated and directed towards a lean direction, the department managers are supplied with relevant information. As a consequence, they can make focused decisions based on good quality information. This might have a positive influence on the company's inventory management, which in turn is favourable for their overall performance, according to Ogbo and Ukpere (2014). These researchers found out that organisations stand to gain a lot from effective inventory control management. Examples are an optimal use of resources, cost reduction, improved profitability, improved sales effectiveness, reduction of waste, transparency and accountability, easy storage and

retrieval of stock and high inventory utilisation amongst others (Ogbo & Ukpere, 2014). The solution above also partly solves the other problems that were identified, namely that the department managers obtain too less information to make focused decisions and that the controller sends too much (irrelevant) information when the department manager asks for more. Implementing lean information management ensures that department managers are supplied with the information they need. This means they do not have to bother the controller for extra information anymore.

Warranty- and complaint costs

The main problem here is that the mechanics are not aware of problems that the department managers are experiencing. Lee, Strong, Kahn and Wang (2002) call this a positive role gap. Organisations with a large positive role gap should focusing on reducing the problem by gaining consensus between, in this case, the mechanics and the department managers. If the size of the gap is small, organisations are positioned to improve the quality of the information, since they have consensus about its level. Another indicator that should be considered is the location of the gap. If the location is low, major improvements efforts have the potential for significant quality improvement, whereas if the location is high (indicating high information quality), incremental improvements are most appropriate. Organisations can measure these indicators by means of the IQ Role Gaps technique developed by Lee et al. (2002). IQ Role Gaps compares the information quality assessments from respondents in different organisational roles, in this case the mechanics and the department managers. Information quality can be assessed by means of a corresponding questionnaire, which can be found in appendix A. The information quality assessment and comparison across roles serves to identify information quality problems and lays the foundation for information quality improvement. However, it is revealed from conversations with the department manager of the department Quality Management that Company X is facing both problems. Therefore, they should focus on both reducing the problem by gaining consensus between the mechanics and the department managers and improving the quality of the information.

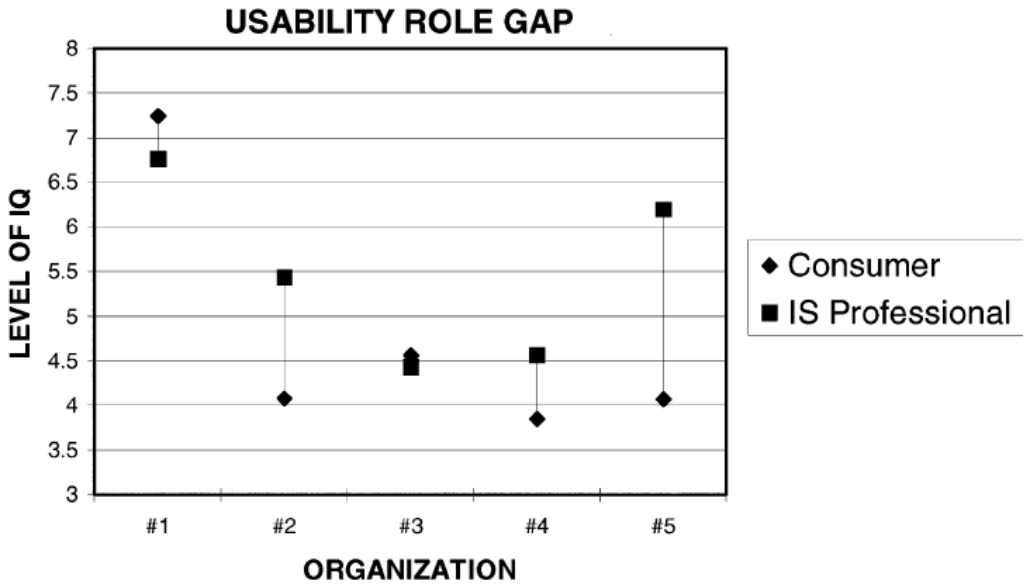

Figure 20. An example of the IQ Role Gap (derived from Lee et al., 2002).

Capacity utilisation

Several department managers at Company X complained about the accuracy of the forecasts. They say the forecasts are inaccurate. This means there is a flawed flow present in the information process of the KPI 'capacity utilisation'. This inefficiency can be eliminated by increasing the forecast accuracy. Danese and Kalchschmidt (2010) pointed out that researchers have devoted particular attention to how forecasting can be improved to increase forecast accuracy (Wright et al., 1986; Armstrong, 2001; Caniato et al., 2002a, b). Several studies have discussed the adaption of both qualitative and/or quantitative forecasting techniques as an important opportunity to increase forecast accuracy (Mentzer & Cox, 1984; Dalrymple, 1987; Sanders & Manrodt, 1994; Sanders & Ritzman, 2001). However, others researchers suggested that adapting forecasting techniques is not enough to guarantee good forecast accuracy. Studies should also consider topics linked on how the forecasting process is organised and managed (Armstrong, 1987; Mentzer & Bienstock, 1998; Moon et al., 2003). The information combined to elaborate forecasts, the role of forecasting in supporting decision making within the company and the techniques adopted are often mentioned as crucial forecasting variables for significantly reducing forecast errors (Fildes & Hastings, 1994; Mentzer & Bienstock, 1998; Moon et al., 2003). As to the forecasting techniques, what seems to be important is using the right approach for the right problem. When demand is highly variable and affected by special events such as promotional activities, and when few historical data is available, judgemental approaches appear to be preferable. Quantitative approaches, on the other hand, are preferable when several forecasts need to be produced, good quality data is available and demand is rather stable (Wright et al., 1996; Makridakis et al., 1998). Moreover, the study of Danese and Kalchschmidt (2010) proves that the earlier mentioned forecasting process variables have a direct impact on companies' operational performance. These researchers argue that this can lead to valuable and useful practical findings, *"it suggests to managers that the forecasting process needs to be designed coherently with the aim that should be achieved, which is not necessarily that of improving forecast accuracy"* (Danese & Kalchschmidt, 2010). Thus, Company X should increase its forecast accuracy by means of rethinking its forecasting techniques and forecasting process, and redesign it with the aim that should be achieved. Next to an accurate forecast, a proper forecasting process gives Company X the opportunity to better understand market dynamics and customers' behaviours, reduces uncertainty on future events, and provides the company's functions with useful analyses and information (Dane & Kalchschmidt, 2010).

Productivity

The problems that were identified in the information process for productivity can be solved with simple organisational solutions. First of all, the company has to make sure that the responsibility of sending the weekly overview to the department managers is assigned to another employee when the controller is absent. With this measure, the problem of not receiving the missing week the week thereafter is also solved. Another problem that has happened very recently is that the changes in cost centres were not reported properly when the department manager of Production Assembly was absent. As a consequence, wrong information was included in the OPM sheets and reported to the holding. The company can prevent this by embedding an extra control in the processes, just like is done in the information process of the indicator 'on time completion'. In the case of the indicator 'productivity', the process should be structured as in figure 21. However, this is only an example. It would be wise to embed such a control in every single information process with regard to the key performance indicators that are reported to the holding.

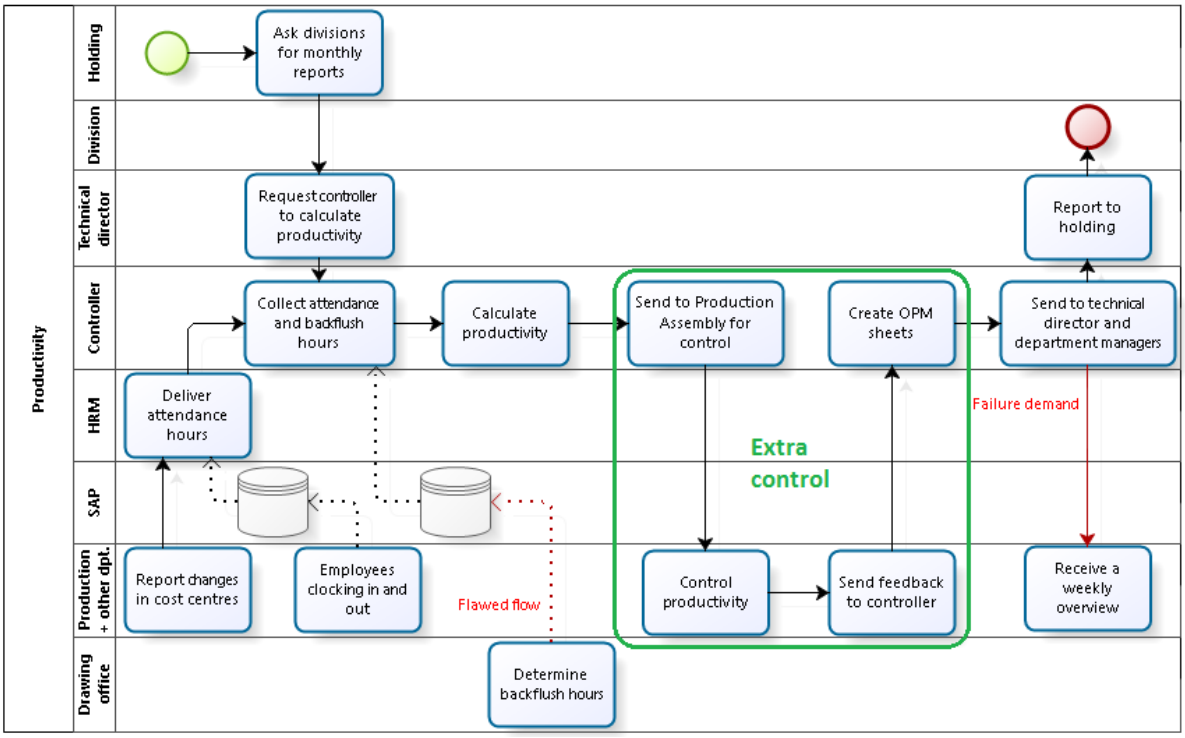

Figure 21. The fixed information process of the KPI 'productivity'.

5. Conclusion and recommendations

5.1. Summary and discussing of findings

Perfection, the fifth and last lean-principle, is defined by its original authors as the *"complete elimination of muda so that all activities along a value stream create value"* (Womack & Jones, 1996, p. 308). This principle makes the pursuit of lean a never-ending process, because there will always be activities that are considered waste in the value stream. The complete elimination of waste is therefore more a desired end-state than a truly achievable goal (Weigel, 2000). Nevertheless, organisations should strive to achieve perfection with regard to information waste in information processes. The main purpose of this research project was to design a method for information waste identification in management reports, in order to identify focused improvements. In order to apply the method at Company X, four sub questions were formulated. The goal of the first question was to determine the value of information from the perspective of the end-user. In this case, valuable information are the KPIs that support Company X's activities and their ability to undertake work. By means of Biazzo and Garengo's circular approach of applying the BSC, the company's current KPIs were assessed. Eventually, all KPIs were considered as relevant, despite some of them were not used well. Besides, eight new KPIs were developed. These eight new developed KPIs are examples of flow demand. Apparently, Company X was unable to identify these information elements and therefore could not flow. The aim of the second question was to identify the current information processes. By means of conversations with those involved in the information processes, information about the delivery of information was collected. The information processes were modelled with business process modelling software. The purpose of question three and four was to, respectively, determine the optimal situation and develop focused improvements with regard to the information processes to achieve the optimal situation. In total, five information processes were analysed. Ten causes of information waste were identified. Focused improvements for the ten causes of information waste were proposed. The answers to these sub questions together are useful for describing the

characteristics of lean information processes of an organisation. First of all, it is extremely important for an organisation that they are able to identify relevant information elements. If important information processes are not available because the information elements were not identified, the organisation miss important information. Resources and activities are necessary to identify the information elements that need to flow. On the other hand, when irrelevant information elements flow, time and resources are necessary to overcome excessive information. Therefore, there must be alignment between the information producer and the information consumer. If there is no alignment, it is possible that the information consumer receives too less or too much information. Furthermore, the information elements that flow must be accurate, reliable and up-to-date. If they are not, incorrect information flows. Resources and activities are necessary to correct or verify information or unnecessary or inappropriate activities result from its use. To ensure information is reliable, organisations should make sure they know where the information comes from. Finally, information producers should know when the information consumer needs the information. In this way, organisations ensure that only the most accurate and up-to-date information elements flow.

To conclude, an effective method for identifying and eliminating information waste in management reports, the central question of this study, should be able to distinguish relevant from irrelevant information. Besides, it should be able to detect whether or not relevant information is available. Furthermore, the method should be able to identify errors in the delivery processes of information, such as the flow of inaccurate information or information that is unable to flow because the process has not been activated. The method for information waste identification that is designed and tested in this study can be seen as a very effective method. First of all, by means of the circular approach of the BSC, the method was able to distinguish the relevant from the irrelevant KPIs. Furthermore, through the development of BPM models, the researcher was able to identify information wastes in the information processes to which focused improvements were developed. Therefore, if organisations want to review their management reports on information waste, it can be recommended to apply this method.

5.2. Limitations and future research directions

First of all, the effectiveness of the developed method is examined by its developer only. Besides, it has only been applied at one (production) company. Therefore, other researchers should focus on testing the method at several other organisations, also known as β-testing (Van Aken, 2004). Another limitation with regard to the method is that it has been developed for management reports. The first phase therefore contains a BSC analysis. This makes the method less useful when organisations want to review other-related information processes. However, since the other phases are more generic, organisations have to adjust the define phase only. Furthermore, because only the processes were enough substance to cover this research project, other subjects were left aside. This means there is space for future research. An interesting issue is the frequency with which certain information should flow, for example KPIs. Hicks (2007) referred to information waste as the costs of too less or too much information, and inaccurate information. However, this author did not explicitly mention the costs of not receiving identified and accurate information elements at the right moment, because the right moment is not identified. Other interesting issues for future research are information quality issues, because these may cause flawed flow. If, for example, the time frames of information derived from different sources is different, inaccurate information flows resulting in inappropriate downstream activities, corrective action or verification.

References

Ahn, H. (2001). Applying the balanced scorecard concept: an experience report. *Long range planning , 34*(4), 441-461.

Armstrong, J. S. (1987). The forecasting audit. In S. Makridakis, & S. C. Wheelwright, *The Handbook of Forecasting* (pp. 584-602). New York: John Wiley.

Armstrong, J. S. (2001). *Principles of Forecasting: A Handbook for Researchers and Practitioners.* Boston: Kluwer.

Ballou, D. P., & Pazer, H. L. (1985). Modeling data and process quality in multi-input, multi-output information systems. *Management Science, 31*(2), 150-162.

Barr, S. (2010). *Building Your Hierarchy of Measures and KPIs*. Retrieved September 2015, from KPILibrary: https://kpilibrary.com/topics/building-your-hierarchy-of-measures-and-kpis

Bevilacqua, M., Ciarapica, F. E., & Paciarotti, C. (2015). Implementing lean information management: the case study of an automotive company. *Production Planning & Control, (ahead-of-print)*, 1-16.

Biazzo, S., & Garengo, P. (2012). The Balanced Scorecard for SMEs: A Circular Approach. In *Performance Measurement with the Balanced Scorecard* (pp. 23-38). Springer Berlin Heidelberg.

Caniato, F., Kalchschmidt, M., & Verganti, R. (2002b). A forecasting approach to manage composite demand. In J. K. Christiansen, & H. Boer, *Operations Management and the New Economy* (pp. 227-238). Denmark: Copenhagen Business School.

Caniato, F., Kalchschmidt, M., Ronchi, S., Verganti, R., & Zotteri, G. (2002a). Forecasting demand fluctuations due to promotional activities: a case in the fresh food industry. *Proceedings of the POMS Conference.* San Fransisco.

Chenhall, R. (2003). Management control system design within its organizational context: Findings from contingency-based research and directions for the future. *Accounting, Organizations and Society, 28*(2-3), 127-168.

Dalrymple, D. J. (1987). Sales forecasting practices: results of a United States survey. *International Journal of Forecasting, 3*, 379-392.

Danese, P., & Kalchschmidt, M. (2011). The role of the forecasting process in improving forecast accuracy and operational performance. *International Journal of Production Economics, 131*(1), 204-214.

Delone, W. H., & McLean, E. R. (1992). Information systems success: the quest for the dependent variable. *Information systems research, 3*(1), 60-95.

Doran, G. T. (1981). There's a S.M.A.R.T. way to write management's goals and objectives. *Management Review (AMA FORUM), 70*(11), 35-56.

Fildes, R., & Hastings, R. (1994). The organization and improvement of market forecasting. *Journal of the Operational Research Society, 45*, 1-16.

Goodhue, D. L. (1995). Understanding user evaluations of information systems. *Management Science, 41*(2), 1827-1844.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly: Management Information Systems, 28*(1), 75-105.

Hicks, B. J. (2007). Lean information management: Understanding and eliminating waste. *International Journal of Information Management, 27*(4), 233-249.

Hicks, B. J., Culley, S. J., & McMahon, C. A. (2006). A study of issues relating to information management across engineering SMEs. *International Journal of Information Management, 26*(4), 261-283.

Hoque, Z. (2013). *Celebrating 20 years of the Balanced Scorecard: relevance lost or relevance gained and sustained?* Melbourne: La Trobe University.

Hudson, M., Lean, J., & Smart, P. A. (2001). Improving control through effective performance measurement in SMEs. *Production Planning & Control, 12*(8), 804-813. doi:10.1080/09537280110061557

Jarke, M., & Vassiliou, Y. (1997). Data warehouse quality: a review of the DWQ project. *Proceedings of the Conference on Information Quality* (pp. 299-313). Cambridge: MA.

Kaplan, R. S., & Norton, D. P. (1992). The Balanced Scorecard – Measures That Drive Performance. *Harvard Business Review, 70*(1), 71-79.

Kaplan, R. S., & Norton, D. P. (1996). Using the balanced scorecard as a strategic management system. *Harvard Business Review, 74*(1), 75-85.

Kaplan, R. S., & Norton, D. P. (1998). Putting the balanced scorecard to work. *The Economic Impact of Knowledge*, 315-324.

Kaplan, R. S., & Norton, D. P. (2000). Having Trouble with Your Strategy? Then Map It. *Harvard Business Review, 78*(5), 167-176.

Kashani, N. (2011). *Evaluation of BPM tools for process management in organizations.* Hasselt: University of Hasselt.

Larson, R. R. (2005). *Information life cycle. A model of the social aspects of digital libraries.* Retrieved from /http://www.sims.berkeley.edu/courses/is202/

Lee, Y. W., Strong, D. M., Kahn, B. K., & Wang, R. Y. (2002). AIMQ: a methodology for information quality assessment. *nformation & management, 40*(2), 133-146.

Makridakis, S., Wheelwright, S., & Hyndman, R. J. (1998). *Forecasting: Methods and Applications.* New York: Wiley.

Marr, B., & Schiuma, G. (2003). Business performance measurement – past, present and future. *Management Decision, 41*(8), 680-687.

Mentzer, J. T., & Bienstock, C. (1998). *Sales Forecasting Management.* London: Sage Publications.

Mentzer, J. T., & Cox, J. E. (1984). Familiarity, applications, and performance of sale forecasting techniques. *Journal of Forecasting, 3*, 27-36.

Moon, M. A., Mentzer, J. T., & Smith, C. D. (2003). Conducting a sales forecasting audit. *International Journal of Forecasting, 19*, 5-25.

O'Connor, M., Remus, W., & Griggs, K. (2000). Does updating judgmental forecasts improve forecast accuracy? *International Journal of Forecasting, 16*(1), 101-109.

Ogbo, A. I., & Ukpere, W. I. (2014). The Impact of Effective Inventory Control Management on Organisational Performance: A Study of 7up Bottling Company Nile Mile Enugu, Nigeria. *Mediterranean Journal of Social Sciences, 5*(10), 109-118.

Parmenter, D. (2007). *Key performance indicators: Developing, implementing, and using winning KPIs.* Hoboken: John Wiley & Sons.

Richman, L. L. (2011). *Improving your Project Management Skills* (2nd ed.). New York: American Management Association.

Rigby, D., & Bilodeau, B. (2011). *Management Tools & Trends 2011.* London: Bain & Company.

Rigby, D., & Bilodeau, B. (2013). *Management Tools & Trends 2013.* London: Bain & Company.

Rigby, D., & Bilodeau, B. (2015). *Management Tools & Trends 2015.* London: Brain & Company.

Sanders, N. R., & Manrodt, K. B. (1994). Forecasting practices in US corporations: survey results. *Interfaces, 24*(2), 92-100.

Sanders, N. R., & Ritzman, L. P. (2001). Judgmental adjustment of statistical forecasts. In J. S. Armstrong, *Principles of forecasting: A Handbook for Researchers and Practitioners.* Boston: Kluwer Academic Publishers.

Shahin, A., & Mahbod, M. A. (2007). Prioritization of key performance indicators: An integration of analytical hierarchy process and goal setting. *International Journal of Productivity and Performance Management, 56*(3), 226-240.

Taticchi, P., Tonelli, F., & Cagnazzo, L. (2010). Performance measurement and management: a literature review and a research agenda. *Measuring Business Excellence, 14*(1), 4-18.

Van Aken, J. E. (2004). Management research based on the paradigm of the design sciences: the quest for field-tested and grounded technological rules. *Journal of Management Studies, 41*(2), 219-246.

Van den Berg, W. (2015). *A Systems Approach to the design of a Management Information System for a growing IT service company.* University of Twente, Enschede.

Wang, R. Y., & Strong, D. M. (1996). Beyond accuracy: what data quality means to data consumers. *Journal of Management Information Systems, 12*(4), 5-34.

Weigel, A. L. (2000). A Book Review: Lean Thinking by Womack and Jones. *Research Seminar in Engineering Systems*.

Womack, J. P., & Jones, D. T. (1996). *Lean thinking: Banish Waste and Create Wealth in Your Corporation.* London: Simon and Schuster.

Womack, J. P., Jones, D. T., & Roos, D. (1990). *The Machine That Changed The World.* Toronto, Canada: Collier Macmillan.

Wright, D. J., Capon, G., Page, R., Quiroga, J., Taseen, A. A., & Tomasini, F. (1986). Evaluation of forecasting methods for decision support. *International Journal of Forecasting, 2*(2), 139-153.

Wright, G., Lawrence, M. J., & Collopy, F. (1996). The role and validity of judgment in forecasting. *International Journal of Forecasting, 12*(1), 1-8.

Zmud, R. (1978). Concepts, theories and techniques: an empirical investigation of the dimensionality of the concept of information. *Decision Sciences, 9*(2), 187-195.

Appendices

Appendix A: A questionnaire for information quality assessment

This questionnaire is derived from Lee et al. (2002). All items are measured on a 0 to 10 scale where 0 is not at all and 10 is completely. Items labels with ‘‘(R)’’ are reverse coded.

Accessibility. (4 items, Cronbach’s Alpha = .92)

- This information is easily retrievable.
- This information is easily accessible.
- This information is easily obtainable.
- This information is quickly accessible when needed.

Appropriate Amount. (4 items, Cronbach’s Alpha = .76)

- This information is of sufficient volume for our needs.
- The amount of information does not match our needs. (R)
- The amount of information is not sufficient for our needs. (R)
- The amount of information is neither too much nor too little.

Believability. (4 items, Cronbach’s Alpha = .89)

- This information is believable.
- This information is of doubtful credibility. (R)
- This information is trustworthy.
- This information is credible.

Completeness. (6 items, Cronbach’s Alpha = .87)

- This information includes all necessary values.
- This information is incomplete. (R)
- This information is complete.
- This information is sufficiently complete for our needs.
- This information covers the needs of our tasks.
- This information has sufficient breadth and depth for our task.

Concise Representation. (4 items, Cronbach’s Alpha = .88)

- This information is formatted compactly.
- This information is presented concisely.
- This information is presented in a compact form.
- The representation of this information is compact and concise.

Consistent Representation. (4 items, Cronbach’s Alpha = .83)

- This information is consistently presented in the same format.
- This information is not presented consistently. (R)
- This information is presented consistently.
- This information is represented in a consistent format.

Ease of Operation. (5 items, Cronbach’s Alpha = .85)

- This information is easy to manipulate to meet our needs.
- This information is easy to aggregate.
- This information is difficult to manipulate to meet our needs. (R)
- This information is difficult to aggregate. (R)
- This information is easy to combine with other information.

Free of Error. (4 items, Cronbach’s Alpha = .91)

- This information is correct.
- This information is incorrect. (R)
- This information is accurate.
- This information is reliable.

Interpretability. (5 items, Cronbach’s Alpha = .77)

- It is easy to interpret what this information means.

- This information is difficult to interpret. (R)
- It is difficult to interpret the coded information. (R)
- This information is easily interpretable.
- The measurement units for this information are clear.

Objectivity. (4 items, Cronbach's Alpha = .72)

- This information was objectively collected.
- This information is based on facts.
- This information is objective.
- This information presents an impartial view.

Relevancy. (4 items, Cronbach's Alpha = .94)

- This information is useful to our work.
- This information is relevant to our work.
- This information is appropriate for our work.
- This information is applicable to our work.

Reputation. (4 items, Cronbach's Alpha = .85)

- This information has a poor reputation for quality. (R)
- This information has a good reputation.
- This information has a reputation for quality.
- This information comes from good sources.

Security. (4 items, Cronbach's Alpha = .81)

- This information is protected against unauthorized access.
- This information is not protected with adequate security. (R)
- Access to this information is sufficiently restricted.
- This information can only be accessed by people who should see it.

Timeliness. (5 items, Cronbach's Alpha = .88)

- This information is sufficiently current for our work.
- This information is not sufficiently timely. (R)
- This information is not sufficiently current for our work. (R)
- This information is sufficiently timely.
- This information is sufficiently up-to-date for our work.

Understandability. (4 items, Cronbach's Alpha = .90)

- This information is easy to understand.
- The meaning of this information is difficult to understand. (R)
- This information is easy to comprehend.
- The meaning of this information is easy to understand

Appendix B: A classification of information management issues with respect to waste

No.	Issue	Implications for waste	Waste category
1	Information exchange	Inability to automatically exchange information and enable value to flow results in additional processes necessary to overcome this lack of functionality/poorly functioning process	Flow demand
2	Manual systems and data entry	Processes and resources necessary to overcome information exchange and also where processes are unavailable	Failure demand
3	Monitoring, control and costing	Information is required but has not been generated and cannot flow	Flow demand

4	Information flow from customers and/or sales	Information does not flow and processes are not well defined so additional effort is necessary to acquire information	Failure demand and flow demand
5	Functionality of IS	Inability to perform certain functions to support the management and flow of information requires additional resources	Failure demand
6	Information storage	Excessive information is stored, partly because of a lack of understanding of potential value	Flow excess
7	End-user developed applications over Commercial Off-The-Shelf (COTS) information systems	Acquisition of additional resources to overcome existing process limitations and also in an attempt to minimize cost (waste)	Failure demand and waste reduction
8	Information systems use and maintenance	Activities are perceived as a waste by members of the organisation but arguably undertaking these activities might improve flow and eliminate waste	Value
9	Numbering and traceability of machines, assemblies and parts	Additional effort required to locate up-to-date/accurate build	Flow demand
10	Information availability and accessibility	Time and effort necessary to identify information to flow and unavailability of processes to support flow	Flow demand and failure demand
11	Information systems implementation and customization	Activities are perceived as a waste by members of the organisation but arguably undertaking these activities might improve flow and eliminate waste	Value
12	Information identification, location and organisation	Resources necessary to identify the information to flow The level of resources increases as the amount of information increases	Flow demand and flow excess
13	Information completeness and accuracy	Effort necessary to verify and/or correct information and the effect of its use	Flawed flow
14	Implementation and operation of quality systems	Activities are perceived as a waste by members of the organisation because the value to the organisation is not understood or insufficient	Value
15	Information duplication	Effort necessary to arbitrate between multiple instances of information	Flow demand and flawed flow

16	Information currency	Out-of-date or inaccurate information requires additional effort to verify and/or update information	Flawed flow
17	Paper systems over COTS information systems	Master records are maintained in an effort to reduce waste however they may arise due to failure of existing processes	Waste reduction and failure demand
18	Information systems strategy and planning	A lack of understanding of the value of information and its flow across the organisation can result in a poorly performing system and arguably waste	Value and waste