



BACHELOR'S THESIS

INCREASING THE ACCURACY OF COST ACCOUNTING AT COMPANY X

A case study to enable management to manage and monitor
manufacturing costs more accurately

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Preface

I hereby present my thesis for the bachelor's programme in Industrial Engineering & Management at the University of Twente. This thesis contains several methods and tools focussing on increasing the accuracy of cost accounting at a manufacturing company. The goal of my research is to enable the managers of the company to reduce the manufacturing cost variance more effectively. In this preface, I would like to express my gratitude to the people that supported me during my internship.

In February 2020, I started my research at Company X, a subsidiary of Company Y. After a few weeks, my supervisor, Manager A, was offered a different position at Company X, so Production Manager took over and supported me during my research the following months. I would like to thank Jeroen for introducing me to the company and for putting me at ease on my first days. In addition, I would like to thank Production Manager for taking over as supervisor and for contributing to my research.

In March 2020, the coronavirus appeared in the Netherlands. Because of this, I had to work from home, causing some difficulties and requiring even more self-directedness. In addition, the demand for products of another subsidiary of Company Y increased significantly, demanding more time from Production Manager and Manager B, the managing director of Company X. I really appreciate Production Manager and Manager B for putting effort into supporting me and my research despite this extraordinary situation. Furthermore, I would like to thank the ICT department of Company X for offering resources for working from home. I am also thankful for the inspiring working environment created by my colleagues at the times I worked at the company.

Reinoud Joosten has been an indispensable tutor during the past months as well. I would like to thank him for sharing his expertise and professional experience and for supervising my research. He also helped me improve my academic skills, which I really appreciate. Furthermore, I would like to thank Wouter van Heeswijk for the involvement as second thesis supervisor and examiner from the university. I would also like to thank my good friend Wessel Smits for his support and constructive feedback during the past months. Last not but least, I am very grateful to my parents for supporting me in these extraordinary times.

The bachelor's programme in Industrial Engineering & Management has been very informative. I gained many insights into the fields of industrial engineering and industrial management, improved my academic skills and became a better self-directed learner. The past three years provided a good foundation for my professional career. I am really looking forward to the next challenge: Solar Team Twente.

Mark van Eijk
Enschede, July 8, 2020

Management Summary

Cost reduction: a challenge for every company. Cost accounting is the process of identifying, monitoring and managing costs. Accurate cost accounting is essential for obtaining useful information and it eases the process of cost reduction. In this report, I elaborate on my literature study on accounting methods ensuring maximum accuracy of cost accounting. In addition, I apply the findings by developing and delivering new cost accounting tools for Company X, a manufacturing company. I developed these tools to ensure that accurate and useful information about costs is provided to the managers of the company, thereby facilitating decision-making processes. The information provided by the tools focusses on analysing the difference between the actual and expected manufacturing cost, known as the manufacturing cost variance (Hilton, 2011). By monitoring this variance as accurately as possible, high and unexpected manufacturing costs can be averted more effectively. Detailed analyses ease the process of reducing the cost variance. The main research question in this report is therefore stated as follows:

Which cost accounting methods should be applied to reduce the manufacturing cost variance at Company X?

This research question is tackled by applying the Managerial Problem-Solving Method (Heerkens & Van Winden, 2017). This method includes seven stages, from identifying core problems to implementing and evaluating the solution generated.

Before developing the new tools in Microsoft Excel, I have analysed the ones currently used at the company to identify problems and opportunities for improvement. The tools include several inaccuracies and exclude useful parameters for accurate cost accounting. Moreover, they do not enable the managers to analyse cost variances, lacking a useful measure for assessing the performance of the production process. To eliminate the problems observed, I have performed a literature study on methods for cost accounting and cost variance analysis. This study is focussed on finding methods that enable the managers of Company X to perform cost variance analyses and increase the accuracy of the accounting tools. I have applied the most suitable methods found in this literature study to the tools I developed for the company.

Cost accounting has three objectives: cost ascertainment, cost control and cost audit (Arora, 2013). Cost ascertainment, also known as product costing, is about identifying costs. At Company X, a price calculation tool is used for this purpose. The company engages in business-to-business transactions involving fixed price contracts. This means that selling prices are set before the manufacturing of the specific order starts. So, accurate cost ascertainment is essential for achieving the profitability levels desired. The tool currently used for this purpose generates a cost price forming a basis for the selling price. The tool does not allocate non-manufacturing overhead costs to the specific product. Non-manufacturing overhead costs, also known as operating expenses, are not directly related to the production of a product, meaning these costs are incurred no matter how many products are being produced. Non-manufacturing overhead costs have to be covered by the products sold, meaning a well-motivated computation of the amount to be covered by each product has to be included in the price calculation. In the price calculation tool I developed for the company, I implemented activity-based costing for allocating the non-manufacturing overhead costs. This allocation is based on the machine capacity utilisation of the product, meaning a product requiring relatively more machine hours and machine runs covers relatively more overhead costs. This method encourages the managers implicitly to increase production and make full use of the machine capacity of the production facility, since this would require less overhead costs to be covered per machine hour and machine run. This would increase the profit margins of the products if the same selling prices are used. It would also enable the managers to set lower selling prices with the same profit margins, possibly leading to more sales.

The second objective of cost accounting is cost control. Cost control is about monitoring and managing costs. The managers of Company X use a performance evaluation tool for these purposes. The tool is

used weekly and provides information about the performance of the production process. It includes general financial results, such as the net result and sales revenue, and product-specific results. The tool includes several inaccuracies and rough estimations of actual costs. For example, the cost of goods sold is computed based on a general percentage of the sales revenue, instead of an estimation of the costs actually incurred. Furthermore, the performance evaluation tool and price calculation tool are not connected, meaning that actual results are not compared with expected results. Because of this, a useful measure for assessing the actual performance of the production process is lacking. Moreover, a cost variance analysis cannot be performed. In the performance evaluation tool I developed, I divided the actual manufacturing cost into its three components: direct material costs, direct labour costs and manufacturing overhead costs. The actual costs of these three components are computed for each step of the production process and for each product. Whenever possible, actual rates are used. However, standard rates, also known as expected or budgeted rates, are used for some parts, since the current way of working at Company X does not always enable the use of actual rates. For each product, the standard rates are computed in the price calculation tool I developed and should be copied to the new performance evaluation tool. In addition, standard unit costs should be inserted into the performance evaluation tool, enabling the managers to perform cost variance analyses. A detailed cost variance analysis is shown on the dashboard, which is the first sheet of the performance evaluation tool I developed. This analysis includes the cost variance for each product and for the following components: manufacturing cost, direct labour cost, manufacturing overhead cost, metal injection moulding, sintering and post-processing. The latter three components are the main parts of the production process. A negative cost variance at the metal injection moulding process would indicate more costs are incurred by this process than expected. Because of the detailed cost variance analysis in the new tool, the managers can identify bottlenecks more quickly, enabling them to avert higher costs more quickly and more effectively. The communication of cost information, such as cost prices and cost variance analyses, to the managers is known as cost auditing, which is the third objective of cost accounting.

Implementing the tools I developed would increase the accuracy of the calculations for cost accounting purposes, meaning more accurate and more useful information is obtained. This information facilitates the decision-making processes of the managers, enabling them to make better-informed decisions. Activity-based costing is the most accurate costing method to implement in the price calculation tool for overhead allocation if a cost-plus pricing strategy is applied. This product costing method provides a more detailed overview of all costs incurred by the activities of the company and eases cost reduction (Arora & Raju, 2018). Absorption costing is the most suitable financial reporting method to implement at Company X, since it is easy to implement and enables easy comparison with results previously realised. The cost variance is the most effective measure for assessing the performance of the production process at the company. The performance evaluation tool I developed provides a detailed cost variance analysis, enabling the managers to eliminate bottlenecks quickly and effectively. However, it still includes some inaccuracies, since the current way of working at the company does not enable the use of actual rates for all components of the manufacturing cost. For example, the actual direct material cost cannot be computed for each product, since the amount of materials used for each product is not tracked by the employees. Therefore, the managers cannot compute the direct material cost variance, limiting the effectiveness of the cost variance analysis. The managers should focus on increasing the accuracy of the calculations even more. In particular, they should try to facilitate the employees to track and monitor processing-times and resource consumption of the products in every step of the production process. This way, the actual costs can be more accurately computed, increasing the accuracy of cost variance analysis and thereby enabling the managers to make better-informed decisions to reduce the manufacturing cost variance more effectively.

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Glossary

ABC	Activity-based costing.
Accounting	The identifying, communicating and measuring of mostly financial information about a business entity. (BusinessDictionary, n.d.-a)
BCWP	Budgeted cost of work performed.
Cost price	Price for manufacturing and delivering a product, so without a profit being added. (Cambridge Dictionary, n.d.-e)
Dashboard	The first sheet of the performance evaluation tool, containing a summary of the most important results.
DL	Direct labour costs.
DM	Direct material costs.
EWMA	Exponentially weighted moving average.
Excel	Software by Microsoft for making spreadsheets.
FMOH	Fixed manufacturing overhead costs.
Injection moulding	Manufacturing process for producing complex products or parts by injecting molten material into a mould. The mould has the same shape as the desired product. (BusinessDictionary, n.d.-c)
MIM	Metal injection moulding.
MOH	Manufacturing overhead costs.
MPSM	Managerial Problem-Solving Methodology. A framework for solving action problems, developed by the University of Twente.
Operator	Employee who operates the machines in the production facility.
SMA	Simple moving average.
VMOH	Variable manufacturing overhead costs.
WMA	Weighted moving average.

Chapter 1: Introduction

This chapter provides a general introduction to my research. First, I introduce the organisation for which a problem is tackled. Furthermore, I define the problem and elaborate on the problem-solving approach.

1.1 The Organisation

[this information is removed due to confidentiality]

1.2 The Problem

My research is focussed on solving a problem. This problem is observed by the managers of Company X and therefore known as the management dilemma (Cooper & Schindler, 2014). It requires action by the managers in order to be eliminated. In this section, I elaborate on the management dilemma, its causes and the people experiencing the problem. Moreover, I identify the core problems, which are the focus of the problem-solving approach. Furthermore, the main research question is stated at the end of this section.

1.2.1 Motivation

Among other things, the managers of Company X monitor the financial performance of the production process to facilitate their decision-making. This process is known as managerial accounting. The performance is assessed weekly by using a performance evaluation tool containing several parameters which ought to provide an accurate view on the financial results realised during a specific period. For a manufacturing company, the manufacturing cost is the most important parameter to monitor in such tool. The process of monitoring costs for managerial purposes is known as cost accounting. Currently, the performance evaluation tool does not compare the actual manufacturing cost with the expected manufacturing cost, leading to a lack of useful information about the actual performance of the production process. A price calculation tool is used for computing cost prices and selling prices. This tool should provide targets, which can be used to assess the actual performance in the performance evaluation tool. To assess the actual performance accurately, the price calculation tool should compute the results accurately as well. Incorrectly and inaccurately performed calculations and performance evaluations result in ill-informed decisions by the managers, possibly causing higher costs than expected. The latter problem is stated as the management dilemma (Cooper & Schindler, 2014). The managers realised that the tools currently used might not be as reliable as they should be. This is the reason why the managers were looking for someone who could identify problems and opportunities for improvement in the cost accounting process of Company X.

1.2.2 Stakeholders

My research is mainly carried out at the management department of the company, since the management dilemma is observed here. Currently, the department consists of two managers: the production manager and the managing director. The managing director is the problem owner. He is responsible for the consequences of the problem and determines which actions should be taken in order to solve the problem. Furthermore, the managing director sets the selling price of a product with the use of the price calculation tool, so potential changes to this tool have to be discussed with him.

The production manager, who is one of the supervisors of this project, is responsible for the daily activities at the production facility and creates the production planning. The production manager is an important source for collecting relevant information for my research. Moreover, he is the user of the performance evaluation tool, meaning potential changes to this tool have to be discussed with him. A more detailed analysis of all stakeholders of the project is provided in Appendix A. When generating solutions to the management dilemma, the needs of the two stakeholders were identified and kept in mind.

1.2.3 Core Problems

To tackle the management dilemma, all problems occurring and their causes should be investigated. To start, all problems experienced by the managers and other employees have to be lined up. This way, a problem cluster can be made, providing a clear overview of the relevant problems. This problem cluster is shown in Appendix B. Since the goal is to increase the overall accuracy of cost accounting, several problems should be tackled at the same time, if possible. The problem cluster shows which problems are connected and how they are caused. The problems at the bottom of the cluster, so the ones without a direct cause, are the so-called core problems (Heerkens & Van Winden, 2017). To tackle the management dilemma, these core problems have to be eliminated. The core problems tackled in this report are stated in Table 1, together with the management dilemma.

Management Dilemma	Costs incurred are higher than expected.
Core Problem 1	The price calculation tool does not allocate non-manufacturing overhead costs to products.
Core Problem 2	The performance evaluation tool does not compare actual costs with expected costs.

Table 1: The management dilemma and core problems.

Core Problem 1 is observed in the price calculation tool currently used. This tool does not allocate non-manufacturing overhead to the products. Instead, a large profit margin is used and intended to cover these overhead costs. The value of this profit margin is determined by the managing director based on his professional experience. This core problem is mainly affecting the accuracy of cost prices, influencing the accuracy of selling prices. A selling price set too low can negatively affect profitability. A selling price set too high can scare off potential customers, so the company would miss out on sales.

Core Problem 2 significantly affects the quality of the performance evaluation tool. This tool should provide the managers useful insights to facilitate decision-making processes. However, the tool used at Company X does not compare actual costs with expected costs. If the managers are informed quickly and accurately when the costs are higher than expected, higher costs can be averted. Increasing the accuracy of the computations, however, should be priority first.

1.2.4 Main Research Question

The managers of Company X desire a new price calculation tool and a new performance evaluation tool. According to the managers, the ideal deliverables would be a user-friendly tool that gives real-time insight into the financial performance of the production process and a tool that accurately allocates non-manufacturing overhead costs to products. These new tools should provide the managers useful information about the performance of the production process, facilitating and improving the quality of decision-making processes. The tools should be designed to deliver accurate information, such that the difference between the actual costs and expected costs, known as the cost variance (Hilton, 2011), can be more easily reduced. The manufacturing cost is the main cost of interest, since this is a variable cost that can be easily manipulated. To conclude, the main research question is stated as follows:

Which cost accounting methods should be applied to reduce the manufacturing cost variance at Company X?

1.3 The Problem-Solving Approach

The management dilemma is an action problem (Heerkens & Van Winden, 2017). A situation that is not as you want it to be and therefore requires intervention, is described as an action problem. This type of problems can be tackled by applying the Managerial Problem-Solving Methodology (MPSM) (Heerkens & Van Winden, 2017). This methodology provides a framework for solving action problems in a stepwise manner. The seven stages of the MPSM are shown in Appendix C. In order to solve the core problems, a systematic problem-solving approach has to be formulated, which is the second stage of the MPSM. I formulate this approach by keeping the steps of the D3-approach of Heerkens & Van Winden

(2017) in mind. This approach has three stages: Do, Discover and Decide. First, I discuss the actions that have to be taken to help the managers solve the problem. These actions are formulated as the deliverables I provide to the managers. Second, I formulate research questions, which should retrieve relevant knowledge for creating the deliverables and generating solutions. The third stage of the D3-approach is about selecting the right options and making the right decisions to maximise the contribution and relevancy of the deliverables. This stage is included in the research design, elaborating on the use of data collection and data analysis methods which should support the decision-making process. An overview of some of the research designs applied can be found in Appendix D.

1.3.1 Deliverables

My goal is to enable the managers of Company X to reduce the difference between the actual and expected manufacturing cost. This can be done by increasing the accuracy of the cost accounting process. For this purpose, I developed a new price calculation tool and a new performance evaluation tool. The new price calculation tool includes a well-motivated non-manufacturing overhead allocation. The performance evaluation tool is designed to provide accurate information about the actual performance of the production process quickly. The two tools are connected to each other to enable the managers to compare actual results with expected results. Recommendations and user manuals are provided to Company X as well to ease the process of implementing the new tools.

1.3.2 Research Structure

The management dilemma is tackled by applying the MPSM (Heerkens & Van Winden, 2017). Each stage of the MPSM is elaborated in a different chapter of this thesis. Moreover, in each stage, a different research question is treated. The answers to these research questions help solve the management dilemma and provide a more detailed approach to the subject. Table 2 shows the research questions and the corresponding chapter of the thesis and stage of the MPSM.

MPSM Stage	Chapter	Research Question
1	1	What is the problem?
2	1	How am I going to tackle the problem?
3	3	What does the current cost accounting process look like at Company X?
4	4	Which methods can be applied to improve the accuracy of cost accounting?
5	5	Which methods are the most suitable for Company X?
6	6	How should the most suitable methods be implemented at Company X?
7	7	How can the proposed solutions be improved?

Table 2: The research questions and the corresponding MPSM stage and thesis chapter.

Chapter 2: Theoretical Framework

My research focusses on improving the accuracy of the cost accounting process at Company X to enable the managers to reduce the manufacturing cost variance. But what is cost accounting exactly? And why should the cost variance be reduced? This chapter provides a theoretical introduction to my research, including definitions of concepts frequently used. Furthermore, I elaborate on the objectives of cost accounting and the importance of accurate cost accounting and cost variance analysis.

2.1 What is Cost Accounting?

The Cambridge Dictionary (Cambridge Dictionary, n.d.-c) defines cost accounting, also called cost management, as “the process in which all the costs of a business activity or production process or activity are examined in order to help managers decide how to make profits or save money”. Lexico, an initiative from Oxford University and Dictionary.com, defines cost accounting as “the recording of all the costs incurred in a business in a way that can be used to improve its management” (Lexico, n.d.). Both sources mention that cost accounting should facilitate the decision-making process for the managers of a business unit. Hilton (2011) defines a cost accounting system as an accounting system that “accumulates cost data for use in both managerial and financial accounting”. The terms managerial accounting and financial accounting are often used in other literature as well, but what are the differences between managerial accounting, financial accounting and cost accounting?

2.1.1 Difference Between Cost Accounting and Managerial Accounting

Hilton (2011) defines managerial accounting as “the practice of identifying, ..., and communicating financial information to managers for the pursuit of an organisation’s goals”. This process supports the strategic side of management. The Institute of Management Accountants (IMA) defines managerial accounting as “financial reporting and control to assist management” (White & Clinton, 2014). Managerial accounting is a broad concept. It includes several types of financial reporting and accounting with the main purpose to support the decision-making process for the managers of a business.

Managerial accounting involves several financial data of a business, such as cost information and cash flow analyses, but other data as well, such as production results (Hilton, 2011). It provides both quantitative and qualitative information. Cost accounting mainly deals with the quantitative measuring, identifying and reporting of costs incurred by business activities. It includes the comparison of actual costs with expected costs to measure the financial performance of a business unit. This quantitative measurement involves the analysis of all types of costs, such as variable costs, fixed costs, direct costs and indirect costs. The information obtained is ought to help the managers make effective decisions and provides insights into the financial condition of a business.

2.1.2 Difference Between Cost Accounting and Financial Accounting

Cost accounting is an accounting method used for managerial accounting. Managerial accounting provides managers useful insights into the financial condition of the company. The information provided is ought to support the decision-making process for the managers. Financial accounting, on the other hand, reports financial information to stakeholders outside the organisation, such as stockholders and government agencies. Examples of the financial information reported are financial statements and annual reports. The information is obtained by using several accounting methods, such as cost accounting. For financial accounting, cost accounting is used to accumulate historical cost data of the entire organisation (Hilton, 2011).

So, cost accounting is applied to both managerial accounting and financial accounting, but the purpose differs. For financial accounting, cost data are used to report financial information to stakeholders outside the organisation. For managerial accounting, on the other hand, cost data are used to support the decision-making process for the internal stakeholders of the organisation, such as the managers.

2.1.3 Objectives of Cost Accounting

Cost accounting plays an essential role in the management of a business. Several objectives of cost accounting can be found in literature. Arora (2013), for example, divides cost accounting into multiple objectives, with the following three as the main objectives: cost ascertainment, cost control and cost audit. These objectives are treated as the main objectives of cost accounting in this report as well.

According to the Cambridge Dictionary, ascertaining is defined as “the discovery of a fact” (Cambridge Dictionary, n.d.-b). If you ascertain something, you make it certain. In terms of cost ascertainment, this means that the costs are discovered and ‘made certain’. In practice, this means that accountants explore the costs incurred by an operation or process and estimate cost prices. The cost price is the price of manufacturing and delivering a product. Cost ascertainment is also known as product costing and forms the basis of selling prices. At Company X, this is done with the use of the price calculation tool.

The Cambridge Dictionary defines cost control as “the process of controlling how much a company or organisation spends so that costs are not greater than an agreed budget” (Cambridge Dictionary, n.d.-d). Meanwhile, BusinessDictionary defines cost control as “the process or activity on controlling costs associated with an activity, process, or company” (BusinessDictionary, n.d.-b). Moreover, it mentions that cost control involves the comparison and realignment of actual costs and budgeted costs. So, the main objective of cost control is to monitor the costs actually incurred by a process and compare this with the budget agreed on. It forms a basis for the realignment of the actual costs and budgeted costs, such that measures can be taken to reduce the variance. The performance evaluation tool of Company X is an internal accounting control facilitating the process of cost control at the company.

The Chartered Institute of Management Accountants defines cost audit as the “verification of cost records and accounts, and a check on adherence to prescribed cost accounting procedures and their continuing relevance” (Chartered Institute of Management Accountants, 2005). Cost auditing is mainly associated with the verification of the cost accounting process, including cost ascertainment and cost control, and the communication of this with the managers of the company. This information should facilitate the decision-making processes.

2.1.4 Importance of Accurate Cost Accounting

My research is focussed on increasing the accuracy of cost accounting. But why is accurate cost accounting important?

First, it should be questioned what accuracy actually is. What makes something accurate? The Cambridge Dictionary defines accuracy as “the fact of being exact or correct” (Cambridge Dictionary, n.d.-a). Dictionary.com defines accuracy as “the condition or quality of being true, correct, or exact” (Dictionary.com, n.d.). Merriam-Webster (n.d.) of the Learner’s Dictionary of Oxford University defines accuracy as “the degree to which a calculation is exact or correct” or “the ability to do something with skill and without making mistakes”. So, accuracy involves being correct and not making any mistakes. If something is accurate, it is correct. In the context of accounting, accuracy has a similar meaning: it involves numbers, values and calculations that have to be computed correctly, meaning the results should not be doubted.

As described in Section 2.1.3, cost accounting has several objectives. Cost accounting identifies how much a company is spending, what it is spending money on and where unforeseen costs are made. The methods used for cost accounting intend to help the process of analysing the financial performance of a business or process. The main function of a cost accountant is to report this analysis and inform the managers such that they can make better decisions.

Karwowski et al. (2015) show what impact inaccurate valuation of product costs can have. According to the authors, it can lead to “distortions of financial results and the value of inventories” which can result in “an incorrect assessment of the condition of a company”. The authors mainly show that inaccurate product costing leads to false estimations of the financial condition of a company.

Stockholders, managers and other stakeholders would be misinformed, which could have negative consequences for them and the company.

Inaccurate estimations of the cost price and selling price of a product can have a negative impact on the financial results of a company. If the cost price is undervalued, it could lead to financial losses for the company. It would mean that manufacturing costs are higher than budgeted, therefore the profits would be lower than desired. In the worst case, it would mean that the manufacturing costs are higher than the revenue generated, which means no profit is made at all and the company could suffer significant losses. Moreover, if the selling price is lower than it should be, a company could be at risk for charges of predatory pricing practices (Hilton, 2011). Predatory pricing is a pricing strategy to attract customers by having low selling prices. Sometimes, legal action could be taken and a business can be sued for having artificially low selling prices. So, providing inaccurate costing information could be a costly mistake.

If the cost price is overvalued, a company could miss out on sales. This means that, assuming a fixed profit margin, the selling price is probably too high compared to the selling prices of competitors. This could lead to customers preferring the products of the competitors, resulting in less sales for the company than desired.

Inaccurate cost control could lead to losses for the company as well. If the performance evaluation tool does not provide clear insight into the actual costs, false information would be communicated with the managers. This could lead to poor decisions being made by the managers, such as unnecessarily adapting selling prices. Sometimes performance evaluation tools generate inaccurate general financial results as well. The reason for this could be the use of parameters and numbers that are not theoretically substantiated or inaccurately estimated. On first sight, these inaccuracies might not be visible. However, in the long run, they could lead to untraceable losses. So, for cost control, it is essential to monitor exactly how much is spent and where the costs are made. This way, the managers can act quickly if necessary.

Accurate cost ascertainment and cost control are the basis for reliable cost audit. Managers would be well-informed, which would lead to better and more effective decisions being made. The financial reports would be more reliable and would provide more accurate insight into the financial condition of the company or business unit.

2.2 What is a Cost Variance?

A cost variance is the difference between a budgeted or expected amount of a cost and the amount actually incurred (Hilton, 2011). The manufacturing cost variance is the difference between the expected manufacturing costs and the manufacturing costs actually incurred. In this report, the expected cost is formulated as the standard cost. Monitoring and analysing cost variances is especially useful in companies in which budgeting or cost ascertainment play an important role. At Company X, a selling price is set before manufacturing of a product starts, so accurate product costing and pricing are important. Cost control tools should provide the managers accurate insight into cost variances such that the managers can act quickly, cut on costs if possible and thereby avert higher costs. For cost variances to be helpful, the actual cost and standard cost should be accurately estimated. This requires accurate cost accounting tools.

2.3 Summary

Cost accounting is the process of ascertaining, monitoring and communicating costs. It is applied for managerial accounting purposes, meaning it facilitates decision-making processes of the managers of a company. In addition, it is used for financial accounting purposes, meaning it delivers cost information to be reported to stakeholders. Accurate cost accounting is essential to prevent distortion of financial information, financial losses and ill-informed decisions by the managers. To increase the effectiveness of cost control, cost variance analysis could be incorporated. The cost variance is the difference between

the expected cost and the actual cost. A cost variance analysis provides useful insights into actual costs and actual performances, and facilitates decision-making processes of the managers of a company.

Chapter 3: Current Situation

In this chapter, I elaborate on the current cost accounting process of Company X, including cost ascertainment and cost control. First, I elaborate on the production process of the company. Secondly, I discuss the price calculation tool currently used by the managers of the company for cost ascertainment. In Section 3.3, I elaborate on the two tools used for cost control. Moreover, in this chapter, I discuss the methods applied in these tools, as well as the data and other factors that affect their parameters.

3.1 The Production Process

Company X applies a batch production system. In this system, a given quantity of a specific product is produced together (Slack et al., 2013). The batch system, also known as job shop, is often applied at companies producing different types of products with varying specifications. Injection moulding is mostly applied in batch systems, since each product requires a different mould.

Injection moulding is a manufacturing process for producing complex products usually made of polymers. Metal injection moulding uses a mixture of polymers and metal, which distinguishes itself from the traditional method. The polymers in the mixture ease the process of injection moulding for metals. The mixture is used as the feedstock for the injection moulding process to create large numbers of products, such as parts of handcuffs for the national police and keys. A systematic view of the production process is shown in Figure 1.

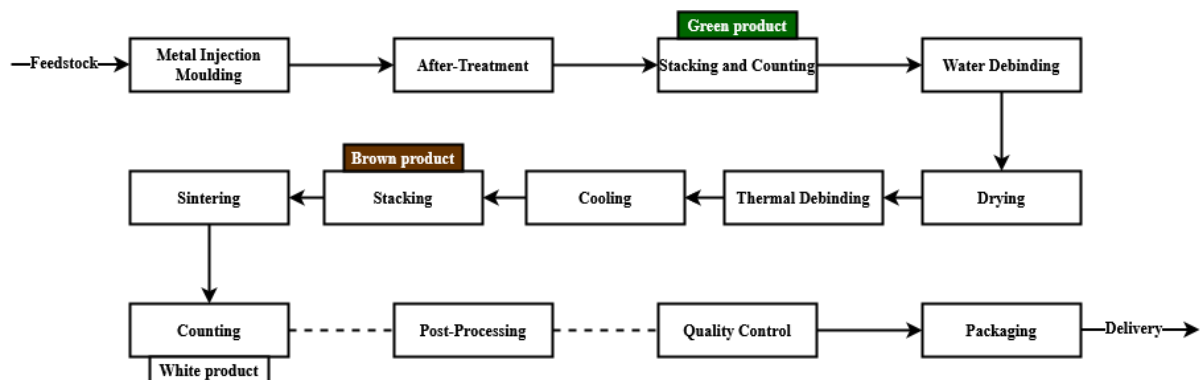


Figure 1: Systematic view of the production process.

Feedstock is inserted into the metal injection moulding machines by the employees, also known as the operators. This feedstock is a mixture of metal powder and three polymers. The feedstock is mixed and mostly stored at the supplier.

At the metal injection moulding machines, the operators check the quality of the products and keep track of the number of products produced. Company X currently owns nine metal injection moulding machines. The operators monitor the process and fill in a production order. This production order includes the number of products produced and the total amount of feedstock used. Furthermore, they track the number of hours they spent on a certain product. The production order is uploaded to the inventory management system at the end of each week. After metal injection moulding, most products require a small after-treatment. This after-treatment mainly consists of removing the sprue and brushing the product. A product is internally labelled as “green” product once it has finished the metal injection moulding process and after-treatment.

The next step of the production process is debinding. Debinding is necessary for removing the three polymers used for injection moulding. The first step of the debinding process is water debinding. The products are stacked on a rack and put in a water bath. The products stay there for 1 to 5 days, resulting in the dissolvment of one of the three polymers. After this process, the products are dried for 24 hours. The second step of the debinding process is thermal debinding. The products are stacked on a rack with plates made of molybdenum with product-specific ceramic tubes between the plates. After stacking, the

products are placed in two furnaces. The two remaining polymers are removed in this process because of their unique melting points. On average, the heating process takes 15 hours, followed by a cooling process of 5 hours. After the debinding process, the product is internally labelled as “brown” product.

After debinding, the products are placed in one of the two sintering ovens. Sintering shrinks the metal products by approximately 13% to the desired dimensions. It involves electrical heating and cooling. Sintered products are internally labelled as “white” products.

After the injection moulding process and sintering process, the products are counted. The results are monitored by the inventory manager and uploaded to the inventory management system. The manager handles the packaging and monitors all post-processing of the products as well. Post-processing includes processes such as hardening and nickel plating. Some processing is done at an external company. Furthermore, most products are sent to an external company for quality control. The quality control is the final step of the production process.

3.2 Cost Ascertainment

Company X makes use of fixed price contracts, meaning orders are made before production starts. This means that selling prices are set before production starts as well, requiring an accurate estimation of the costs to be incurred. A price calculation tool is used for this. This tool is mainly used for managerial accounting purposes. This tool computes a cost price and selling price of a product. Computing the cost price of a product requires knowledge about the cost drivers. These cost drivers involve several types of input data, which I discuss in this section. Furthermore, I elaborate on the product costing and pricing strategy applied in the tool.

3.2.1 Input

The computation of a cost price requires general input data. The following inputs are required for the price calculation in the tool currently used at Company X:

- Machine properties, such as processing times and stack size.
- Machine hour rates.
- Labour hour rates.
- Material properties.
- Order information.
- Mould properties.
- Product failure rates.

Information about the several steps of the production process is used as input for the price calculation tool, as shown in Appendix E. These input values mainly involve the processing time of the product in each step of the production process. These processing times are product-specific. By multiplying these times with machine and labour hour rates, a cost price is estimated. For example, a relatively large product needs relatively more sintering runs for an equal order size, involving a larger total processing time.

Information about the material of the product is used as input for the price calculation tool as well. This includes the price per kilogram and the specific weight. The amount of material used is computed by using the estimated volume of the product. The volume is based on the mechanical properties of the material and the desired weight of the end-product. In addition, information about the order is used as input as well. This mainly includes the annual order size. This number is used for determining the batch size.

Properties of the mould used are important input values for the price calculation. These properties determine the number of products that can be made in a certain time. This number depends on the number of cavities in the mould and on the time needed for a single injection. The number of products produced per injection is equal to the number of cavities in a mould.

With the use of the information about each step of the production process and the product that will be produced, the time needed for each step is estimated. Furthermore, the tool computes the batch size to determine the number of batches for production. Injection moulding possibly uses a different number of batches than the other processes, since it allows for a larger batch size. However, ideally, these batch sizes are equal. In the tool, the batch size after the injection moulding process is equal to the number of products that fit on a single stack for sintering. This batch size depends on the size of the product, meaning a batch is relatively small if products are relatively large. When the batch size is known, the number of batches is computed by dividing the order size by the batch size. For each step after injection moulding, the time needed for a single batch is known. By multiplying the total time needed for each step with the machine hour and labour hour rates, the unit cost price per step of the production process is computed. Figure 2 shows the template of the price calculation tool currently used.

During production, the operators assess the quality of the products. This is done after the injection moulding process and after sintering. To take product failure into account in the calculations, the tool incorporates failure rates. These rates are used as input values for the calculation of the cost price. This rate usually equals 5%, meaning that the company allows for 5% of the total number of products to fail the quality assessment after injection moulding and after sintering.

[this information is removed due to confidentiality]

Figure 2: Calculation template of price calculation tool currently used at Company X.

3.2.2 Product Costing Method

Product costing, also known as cost ascertainment or costing, is the process of assigning costs to an individual product (Hilton, 2011). With this, the cost price of a product is computed. The cost price involves all costs incurred with manufacturing and delivering a product (Cambridge Dictionary, n.d.-e). Figure 2 shows the calculation template used at Company X for the computation of cost prices and selling prices. For each step of the production process, the price calculation tool computes the costs involved based on the product-specific processing times. The processing times are based on several input values discussed in Section 3.2.1. The unit cost per step is based on machine and labour hour rates, which are the main parameters of the tool. As shown in Figure 2, labour costs and machine hour costs are incurred in every step of the production process, based on the consumption by each product. This means that, for example, if product A needs more labour hours for manufacturing than product B, product A includes a higher value of labour costs in the cost price calculation.

Each product requires a certain number of machine hours and labour hours per step of the production process. The hourly rates of machine costs and labour costs are the main parameters of the price calculation tool. The consumption on these parameters by each product is estimated based on input data.

The machine hour rates are based on several aspects, such as depreciation costs of machines, maintenance costs, costs of gas usage and electricity costs. The depreciation of machines is based on the purchasing value and the useful life of the machines. The useful life of an asset, such as a machine, is seen as the life expectancy of the asset (Hilton, 2011). The purchasing value is spread over the estimated useful life of the asset in terms of depreciation costs. For example, a relatively expensive machine with a relatively short estimated useful life implies relatively high depreciation costs per unit time. Maintenance costs, costs of gas usage and electricity costs are based on the costs incurred in the previous year. An hourly rate is computed by combining the costs involved with the machines.

Labour hour rates are based on the costs of direct labour. Direct labour includes the costs incurred by operators, so these costs can be directly attributed to an individual product type. For this, Company X makes use of so-called production orders, tracking the number of hours spent by an operator on a specific product type, as explained in Section 1.1.

3.2.3 Product Pricing Strategy

The process of setting a selling price for a product is called product pricing or pricing. The selling price is based on the cost price and a profit margin. At Company X, the profit margin usually equals 30% of the cost price. This profit margin is based on product prices of competitors and is adapted if necessary. The cost price of a product serves as a lower limit of the selling price, meaning the selling price should not be lower than the cost price. This way, the company ensures that the direct costs incurred with manufacturing a product are covered. This pricing strategy is a variant of cost-plus pricing, which I discuss in Section 4.1.2.1.

3.3 Cost Control

The price calculation tool computes the costs expected to be incurred with manufacturing a product. The performance evaluation tool, on the other hand, measures the manufacturing costs actually incurred. The production manager monitors the financial performance of the process by using this tool weekly. It is mainly used for cost control, which is the process of managing and monitoring the costs incurred during a specific period of time. The performance evaluation tool is essential for the decision-making processes of the managers. Another tool is used monthly and mainly forms a basis for external financial reports. Both accounting tools provide insights into the financial condition of the company.

3.3.1 Performance Evaluation Tool

At the end of each week, the financial performance of the company is evaluated by using a Microsoft Excel tool. This tool, in this report known as the performance evaluation tool, uses two types of input data, namely personnel data and inventory data. Performance indicators are shown on the dashboard of the tool to assess the performance of the production process. Appendix F includes the template of this dashboard. The tool is mainly used for managerial accounting purposes, since the performance indicators provide the managers useful insights into several aspects to facilitate the decision-making processes. In this section, I elaborate on the data and performance indicators used in the tool.

3.3.1.1 Input

The performance evaluation tool requires personnel data and inventory data as inputs. The personnel data include information about the operators, such as the number of hours spent on a specific product. This way, the tool computes how many hours are spent on a specific product in total. The personnel data are gathered with the use of the production orders.

The inventory data are retrieved from the inventory management system. This system shows information about the positional changes of products in the production process. This information includes the number of products of a specific type that went from one step of the process to another. By tracking the inventory changes of the products in the process, the performance evaluation tool computes how much value is created. In the tool, the several steps of the production process are assigned a specific value, implying that a product at the end of the process is worth more than a product in the beginning of the process. For example, a 'white' product is worth 90% of the cost price and a 'green' product is worth 70% of the cost price. The managers estimate these percentages. The valuation of semi-finished products is done to measure the financial added value or losses more accurately. A product rejected at the end of the production process is more costly for the company than a product rejected at the beginning, so the percentages represent the cost of the work performed so far.

3.3.1.2 Key Performance Indicators

Key performance indicators (KPIs) are used to assess the financial performance of the company. These indicators are parameters intended to provide insight into the most important results (Slack et al., 2013). The performance evaluation tool currently used includes the following indicators:

- Production turnover.
- Net result.
- Number of products delivered.

- Value of work-in-process inventory.
- Turnover per step of the production process.
- Production margin.

The indicators are shown on the dashboard by using charts including results from the current week and previous weeks.

The KPI values are calculated in the calculation sheet of the tool. This sheet includes the value of the products at each step of the process. For this, the inventory data are used. The number of products produced at a certain step of the production process is multiplied by the estimated unit value at that point of production. This way, the managers can create an estimation of how much value is created per product type. The production turnover equals the total change in value of all products. This includes the change in value of products delivered as well as work-in-process inventory. Furthermore, the manufacturing cost is estimated. The manufacturing cost includes the purchasing value of goods manufactured and direct labour costs. The purchasing value of the processed products is estimated. A general percentage is used to determine this value. The direct labour costs are estimated using a general hourly rate and the personnel data.

The tool computes the gross result of production by subtracting the manufacturing costs from the production turnover. The gross result is presented as percentage of the production turnover as well, internally known as the production margin. The net result is computed by subtracting the total overhead costs from the gross result. The overhead costs include indirect labour costs and other overhead costs. The managers of the company estimate the values of these costs.

The dashboard of the tool shows some results for each product type. For example, the gross result realised by each product type is shown. In addition, the amount generated by products delivered is shown, known as the sales revenue. Furthermore, a summary of the inventory changes is provided, including the types of products, the number of products processed at each step of the process and the number of hours spent on a specific product.

3.3.2 External Financial Reporting

The managers of Company X evaluate on the financial results at the beginning of each month in another Excel tool as well. This tool is mainly used for financial accounting purposes, in particular for external reporting. It includes a calculation of the operating income, which is also known as the earnings before interest and taxes (Brealey et al., 2017). This calculation involves all types of costs, such as the cost of goods manufactured and operating expenses, also known as non-manufacturing overhead costs or selling, general & administrative expenses. The tool forms the basis for income statements. The income statement is an important financial statement used for reporting the financial results of a company over a specific period (Brealey et al., 2017). Instead of focussing on multiple performance indicators, the financial reports only focus on the operating income and its components. External reporting is not the focus of my research. Instead, I focus on creating an improved performance evaluation tool for managerial accounting purposes. This tool includes financial reporting, but is only focussed on internal reporting instead of external reporting.

3.4 Key Findings

In this chapter, I elaborated on the internal accounting tools currently applied at Company X. I discussed the product costing method applied in the price calculation tool as well as the input values and parameters of the tool. Several factors, such as material costs, labour costs and overhead costs affect the cost price of a product. However, at Company X, the cost price of a product does not fully incorporate all overhead costs. The price calculation tool uses several properties of the production process and the product as inputs, such as order details, mechanical properties of the required material and estimations of the duration of the processes. These inputs provide useful information for estimating the values of the parameters of the tool, such as the number of sintering batches, required labour hours and required

machine hours. Furthermore, Company X applies a mark-up pricing strategy, intending to cover the fixed costs of the company with a profit mark-up. This mark-up is not theoretically substantiated, meaning the tool lacks accurate information about all cost drivers of a product to compute an accurate mark-up for covering all overhead costs. Inaccurate product costing can lead to significant losses, which are, of course, not preferred.

The cost control tools measure the financial performance of the company in specific period of time. The company reflects on the financial results every week and every month by using two different tools. The weekly tool, known as the performance evaluation tool, includes a dashboard presenting KPIs summarising the most important financial results achieved during a specific week, such as the production turnover, net result, number of delivered products, value of work-in-process inventory and the turnover per step of the production process. The values of these KPIs are computed by involving data from the inventory management system and personnel data. The inventory data include inventory changes used for estimating the value created in each step of the process during the specific week. Personnel data is used for computing the direct labour costs incurred by manufacturing activities. With this information, the performance evaluation tool computes the financial results achieved during a specific week. The tool for monthly financial reporting has a different purpose than the performance evaluation tool. It focusses on financial accounting purposes, such as creating external financial reports.

All in all, this chapter made clear which methods and tools are used at Company X to manage and monitor financial information. I observed that the tools used include several inaccuracies. Reasons for this are the use of wrong parameters and the exclusion of other relevant parameters. Furthermore, the tools are not well-structured, difficult to use and do not provide a clear overview of the most important financial results. The performance evaluation tool does not reflect on the standard results computed in the price calculation tool, meaning the managers have no insight into the difference between standard and actual results, lacking clear targets to be used for assessing the actual performance. To conclude, the currently used tools offer room to improve the cost accounting process.

Chapter 4: Cost Accounting Methods

In Chapter 2, I elaborated on the main objectives of cost accounting, namely cost ascertainment, cost control and cost audit. Especially for cost ascertainment and cost control, several methods can be applied. In this chapter, I discuss several product costing methods commonly applied for cost ascertainment. In addition, I elaborate on the relationship between these methods and pricing strategies, since the pricing strategy applied influences the choice for a product costing method. Additionally, I elaborate on common financial reporting methods for cost control purposes. Furthermore, I discuss the relationship between the cost accounting methods discussed and cost variance analysis. With this chapter, I intend to provide a basic understanding on possible methods to apply at Company X as well as on the possible contribution of these methods to increasing the accuracy of the cost accounting tools and to reducing the cost variance.

4.1 Cost Ascertainment

As explained in Section 2.1.3, cost ascertainment, also known as product costing, is the process of identifying the costs involved with manufacturing a product and delivers an estimated product cost, also known as cost price. The price calculation tool of Company X is used for this, as well as for setting a selling price for a product, which is known as product pricing. This tool is elaborated in Section 3.2. The tool computes the standard product cost, which is required for cost variance analysis. In this section, I discuss several product costing methods and pricing strategies commonly applied in practice, as well as the relationship between these methods and strategies.

4.1.1 Product Costing Methods

The computation of the cost price usually involves three components: direct material costs, direct labour costs and manufacturing overhead costs, also known as indirect manufacturing costs. Direct costs are costs that can be directly attributed to a specific product (Hilton, 2011). Manufacturing overhead costs are costs not directly related to production of an individual product, such as salaries of managers and electricity costs (Hilton, 2011). The sum of the direct costs and manufacturing overhead costs is known as the manufacturing cost (McLaughlin, 2014a).

Various methods can be applied for estimating the manufacturing cost and establishing the cost price. The costing methods distinguish by the approach of allocating manufacturing overhead costs, since these costs are often difficult to assign to an individual product. In this section, I discuss three commonly applied costing methods, namely traditional costing, activity-based costing and target costing.

4.1.1.1 Traditional Costing

Traditional costing can be classified into two categories, namely job costing and process costing. Job costing, also known as job order costing, involves a costing system for companies producing different types of products. Costs are allocated to different jobs. A job consists of a certain number of products of the same type produced together, also known as a batch. The job costing system is commonly applied if every product is produced differently, meaning different amounts of labour hours and materials are needed. Process costing, on the other hand, involves a costing system for a single type of product. For each unit produced, the same amount of labour and materials is assumed to be needed (McLaughlin, 2014c).

Traditional costing is one of the easiest costing methods to implement. A simple traditional costing application makes use of a predetermined rate for allocating manufacturing overhead costs to products (McLaughlin, 2014d). Manufacturing overhead is summed up as one cost item. The value of this cost item is then allocated to a cost driver, such as labour hours, by using an overhead rate. So, the overhead costs are incurred by using labour hours with a predetermined overhead rate, meaning for each extra labour hour consumed, extra overhead costs are incurred. In a traditional product costing system, the predetermined overhead rate can include non-manufacturing overhead costs as well.

Traditional costing is easy to implement and easy to use for financial reporting, although it lacks accurate overhead allocation. This lack of accuracy can have negative consequences for decision-making processes of managers. The cost price can be computed by applying Formula 4.1, which involves a predetermined overhead rate. The predetermined overhead rate is computed in terms of manufacturing overhead costs per labour hour. To compute the manufacturing overhead unit cost, the overhead rate has to be multiplied by the number of labour hours per unit. Table 3 includes the abbreviations used in Formulas 4.1, 4.2 and 4.3.

Abbreviation	Meaning
DM	Direct material costs.
DL	Direct labour costs.
MOH	Manufacturing overhead costs.
VMOH	Variable manufacturing overhead costs.
FMOH	Fixed manufacturing overhead costs.

Table 3: Abbreviations of terms used in Formulas 4.1, 4.2 and 4.3.

$$\text{Cost Price (Predetermined Overhead Rate)} = DM + DL + \left(\frac{\text{Total Budgeted MOH}}{\frac{\# \text{ Labour Hours}}{\# \text{ Products Produced}}} \right) \times \quad 4.1$$

Manufacturing overhead contains variable overhead costs and fixed overhead costs. In a traditional costing system, manufacturing overhead can be allocated by using a predetermined overhead rate. It can be allocated by applying absorption costing or variable costing as well. Formulas 4.2 and 4.3 show the computation of the cost price if the absorption costing method or variable costing method is applied. In absorption costing, the budgeted fixed manufacturing overhead costs are allocated based on the number of products produced. This type of costing is the only costing method accepted for external reporting. Variable costing does not include fixed manufacturing overhead costs in the cost price. Instead, these overhead costs are treated as period costs in financial reports, which are discussed in Section 4.2.1.1. In Section 4.2.1.3, I elaborate on the use of variable costing and absorption costing in financial reporting and cost control.

$$\text{Cost Price (Absorption Costing)} = DM + DL + VMOH + \frac{\text{Budgeted FMOH}}{\# \text{ Products Produced}} \quad 4.2$$

$$\text{Cost Price (Variable Costing)} = DM + DL + VMOH. \quad 4.3$$

Table 5 includes numerical examples of the application of the three traditional product costing methods with the same monthly input values, which are shown in Table 4.

Input	Value
Direct material costs (per unit)	€15
Direct labour costs (per unit)	€20
Variable manufacturing overhead costs (per unit)	€5
Fixed manufacturing overhead costs	€50,000
Budgeted manufacturing overhead costs	€100,000
Estimated number of labour hours needed	1,000
Estimated number of products to be produced	10,000

Table 4: Inputs for numerical example of Table 5.

Product Costing Method	Cost Price
Predetermined overhead rate	$\text{€15} + \text{€20} + \frac{\text{€100,000}}{1,000} \times \frac{1,000}{10,000} = \text{€15} + \text{€20} + \text{€10} = \text{€45}$
Absorption costing	$\text{€15} + \text{€20} + \text{€5} + \frac{\text{€50,000}}{10,000} = \text{€15} + \text{€20} + \text{€5} + \text{€5} = \text{€45}$
Variable costing	$\text{€15} + \text{€20} + \text{€5} = \text{€40}$

Table 5: Numerical examples of product costing methods based on estimated monthly results.

Company X applies a variant of the traditional costing method. Some manufacturing overhead costs are incurred by machine hours with a predetermined rate. Furthermore, the price calculation tool includes a calculation of a batch size. This batch size is used for other computations in the tool, since products of the same type are produced together in equally sized batches. So, Company X currently applies a traditional job costing system.

4.1.1.2 Activity-Based Costing

Activity-based costing (ABC) is a two-stage costing method and is getting more attention lately. It enables companies to eliminate the inaccuracies of a traditional costing system. ABC allocates overhead costs more accurately by assigning these costs to so-called ‘activities’ of the company (McLaughlin, 2014b). ABC incorporates non-manufacturing overhead costs in addition to manufacturing overhead costs.

Instead of using one general cost pool, a grouping of individual costs items, overhead costs are assigned to ‘activity cost pools’ which are assigned to the activities of the company (Hilton, 2011). This is known as the first stage of activity-based costing. The activities actually cause the costs. The second stage comprises the allocation of overhead costs to products. In this stage, the costs are allocated to the products depending on their consumption of the activities (Brandl, 2008). First, a cost driver is identified for each activity cost pool, such as machine hours. After this, the overhead costs are allocated to the products in proportions to the amount consumed of the specific activity. Activity-based costing provides a more detailed look into different activities of a production process and delivers a more accurate costing system for companies. However, the implementation process of ABC requires more attention and effort than the implementation of traditional costing. In addition, ABC requires more assumptions and possibly gives a false sense of security due to its high level of detail. In an ABC system, cost ascertainment is of high importance in order to provide an accurate estimation of the cost price. Activity based costing can be used for cost control as well, which is discussed in Section 4.2.1.4.

4.1.1.3 Target Costing

Target costing is an alternative costing method that makes use of reverse engineering. Companies first start with exploring a specific market. The product prices of competitors are analysed and reported. Then, a product price is determined (Hilton, 2011). This pricing strategy is known as competition-based pricing, which is discussed in Section 4.1.2.2. Target costing can also be applied if a value-based pricing strategy is used, which is discussed in Section 4.1.2.3. This pricing strategy focusses on establishing a selling price based on the willingness of customers to pay for the product.

In target costing, the company calculates the cost price, the ‘target cost’ (Hilton, 2011), based on a desired profit margin. The company must stay under this target cost to achieve the profit level. Target costing is commonly used at companies introducing products to a new market. It mainly focusses on increasing competitiveness and profitability of a new product. In a target costing system, accurate cost management is of high importance in order to track the costs actually incurred accurately. The use of target costing can, however, provide an unrealistic target cost, meaning the company could have trouble with staying under this target cost. This could negatively influence profitability.

Table 6 summarises some advantages and disadvantages of the three product costing methods discussed.

Product Costing Method	Advantages	Disadvantages
Traditional Costing	Easy to implement.	Inaccurate and very arbitrary overhead allocation.
Activity-Based costing	Well-motivated overhead allocation; also provides better insights into the actual cost drivers of a product.	Difficult to implement.

Target Costing	Focussed on the willingness of customers to pay for the product.	Could provide an unrealistic target cost, negatively influencing profitability.
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Table 6: Advantages and disadvantages of three product costing methods.

4.1.2 Relationship Between Product Costing and Product Pricing

The pricing strategy and product costing method are closely related to each other. If a new product costing method is implemented, the pricing strategy should be adjusted, and vice versa. Furthermore, the pricing strategy and product costing method are closely related to the overall business strategy. This business strategy involves operations performance objectives, which are of high interest if the company tries to maximise customer satisfaction and increase competitiveness. A company can focus on five aspects, namely quality, speed, dependability, flexibility and cost (Slack et al., 2013). If a company mainly competes by offering low prices, lowering the cost price is a major objective. In general, every company wants to minimise the costs incurred by manufacturing and selling their products or services, especially if the cost objective is one of the major operations objectives.

In this section, I discuss the three most commonly applied pricing strategies, namely cost-plus pricing, competition-based pricing and value-based pricing, and their relationship with product costing.

4.1.2.1 Cost-Plus Pricing

Cost-plus pricing, also known as mark-up pricing or cost-based pricing, is a pricing strategy commonly used. The selling price is computed by adding a profit margin to the cost price. This profit margin is known as the profit mark-up (Hilton, 2011). This mark-up is intended to cover the fixed costs incurred by the entire company. Fixed costs do not depend on the number of products produced. The profit mark-up can be a proportion of the variable costs as well. Then, it is known as a contribution margin, meaning it represents the contribution of the product to the profit (Hilton, 2011).

In some cases, the mark-up is mutually agreed upon by the manufacturer and buyer. In these cases, the costs actually incurred are covered by the buyer. In other cases, the manufacturer and buyer agree upon a fixed price, meaning the manufacturer has to estimate the costs incurred by manufacturing. If the actual costs are higher than estimated, the losses are not covered by the buyer. This pricing strategy involving a fixed price contract is currently applied at Company X. The mark-up is based on the cost price and on selling prices of competitors. Moreover, the mark-up intends to cover some fixed costs and manufacturing overhead costs, since not all overhead costs are incorporated into the cost price. This ex-ante profit margin is merely based on personal experience of the managers, past results and estimated future demand, meaning this margin is not theoretically substantiated.

Cost-plus pricing is usually seen as a simple pricing strategy, since it is quite easy to derive a selling price. It is a useful strategy for businesses dealing with customer contracts to increase customer trust. By using cost-plus pricing, it can be reasonably justified if prices are raised due to increased input costs. This assures transparency into the pricing strategy and thereby increases customer trust (Dholakia, 2018). By using cost-plus pricing, companies can ensure most costs are covered, reducing possible losses. Cost-plus pricing is mainly applied in companies using a traditional costing system or activity-based costing system, since much effort is made into the estimation of the cost price.

Cost-plus pricing usually ignores product prices of competitors, meaning that products might be under-priced or over-priced compared to the market. This usually results in fewer sales or less profit than desired. Besides, cost-plus pricing ignores the willingness of customers to pay a certain amount for the product. So, the company risks missing out on profit.

4.1.2.2 Competition-Based Pricing

Competition-based pricing, also known as competitive pricing is a pricing strategy focussing on selecting a product price based on prices of competitors (Hilton, 2011). By applying this strategy, a company tries to take advantage of the market price. Mostly companies offering similar products apply

this strategy, so manufacturing costs do not vary that much. Competition-based pricing is especially applied at companies using a target costing system.

Companies can choose to set the selling price of a product below the competition, at the competition or above the competition. Start-ups usually set their prices below the competition, believing this strategy will attract more customers in the near future. Companies choose to set a selling price above the competition if they focus on delivering high quality, such that customers believe it is worth to pay more for the product. Choosing to set a price at the competition is usually a safe option. Companies then try to differentiate themselves through other business activities, such as marketing and customer service.

4.1.2.3 Value-Based Pricing

By applying value-based pricing, also known as customer-based pricing, a company tries to estimate how much customers are willing to pay for a product (Campbell, 2020). The company explores the market it is entering and sets a price mainly based on the findings of field research or surveys. With this pricing strategy, companies intend to maximise revenue by charging a price that customers are willing to pay. Value-based pricing is mostly used in companies using a target costing system.

By applying the value-based pricing strategy, companies focus on the perceived value of customers (Hilton, 2011). It enables companies to adapt their products based on customer demand. So, effective marketing is essential, although it takes much time and effort.

Table 7 summarises the motives for each of the three pricing strategies discussed.

Pricing Strategy	Motive
Cost-Plus Pricing	Cost price and profit mark-up.
Competition-Based Pricing	Prices of competitors.
Value-Based Pricing	Price that customers are willing to pay.

Table 7: Motives for each pricing strategy.

4.2 Cost Control

At Company X, a traditional costing system is applied for cost ascertainment, as explained in Section 4.1.1.1. This costing system is connected to the cost control tools. In these tools, the manufacturing cost of a product is part of the inventory account. This inventory account includes the value of finished goods inventory and work-in-process inventory, and depends on the costing method used. In financial reports, the cost price, also known as product cost, affects the value of the cost of goods sold account and thereby affects the reported net result.

As explained in Section 2.1.3, cost control tools are used to monitor the costs involved with a process and compute financial results. Furthermore, the cost control tools should enable the company to accurately compare actual results with standard results, since this is of high interest for the managers. Several methods can be applied to do this. In this section, I discuss the main elements of cost control and possible methods for monitoring and assessing the financial condition of the company. Furthermore, I discuss possible methods enabling the managers to perform cost variance analyses and the relationship between these methods and the product costing methods.

4.2.1 Financial Reporting

Financial reports provide insight into the general financial results realised in a specific period and the overall financial condition of a company. The results are reported to internal stakeholders and external stakeholders, with the latter as a requirement by law. At Company X, external reports are made with the help of the tool described in Section 3.3.2, which I am not focussing on. However, the performance evaluation tool can be used for financial reporting as well, although it should be focussed on internal reporting only. In this section, I elaborate on four commonly applied methods for financial reporting. First, I explain what the difference is between product costs and period costs, since these terms are often used in literature about financial reporting. Additionally, I elaborate on the differences between standard

costing, normal costing and actual costing, since these methods are applied for computing the product costs, which are part of financial reports.

4.2.1.1 Product Costs and Period Costs

Product costs are costs incurred by the manufacturing of a product intended for sale (Hilton, 2011). This includes direct material costs, direct labour costs and manufacturing overhead costs. These costs are directly related to the manufacturing process of the company. Product costs form the cost price of a product and are also known as manufacturing costs, as discussed in Section 4.1.1. Product costs form a basis for the cost of goods sold account, since the product cost is the unit price of these goods.

Period costs are non-manufacturing costs, meaning these are not directly related to the manufacturing of a product (Hilton, 2011). Instead, these costs are incurred with general business activities, such as marketing and sales. Costs such as rent on the office building, office supplies and other costs incurred with non-manufacturing activities are reported as period costs.

4.2.1.2 Standard Costing, Normal Costing and Actual Costing

Several methods can be applied when computing the manufacturing costs, the product costs, actually incurred. But what rate is used for the direct material and direct labour costs? Standard rates? Or actual rates? And what value is used for the manufacturing overhead costs when allocated to the products?

Normal costing is an approach applying actual direct costs to the product cost. Rates used for computing the total direct materials costs and direct labour costs are based on the costs actually incurred by the manufacturing of a product. Standard costing, on the other hand, uses predetermined rates for these direct costs (Hilton, 2011). Overhead rates are in both approaches based on standard values, meaning these rates are based on overhead budgets. The difference between actual overhead costs and standard overhead costs can be charged to the cost of goods sold account. In an actual costing system, only the costs actually incurred are used (Hilton, 2011). Actual costing is the most accurate costing system of the three systems discussed, although product costs can appear to be unstable over time. Besides, financial reports can only be made if the costs actually incurred are known. This amount is known when quotations are received, which usually takes much time. Standard costing provides less accurate cost data than normal costing and actual costing, but enables the managers to perform cost variance analyses.

4.2.1.3 Variable Costing and Absorption Costing

Financial reporting at a company mainly includes setting up an income statement. The income statement, also known as profit and loss statement, is a financial statement used for reporting the financial results realised in a specific financial period and is required by law (Brealey et. al, 2017). It includes several parameters determining the net income of this period, including revenue, expenses, taxes and interest. The income statement is obligatory for external reporting and very useful for internal reporting as well. Two methods are very common for financial reporting, namely variable costing and absorption costing.

Absorption costing, also known as full costing, is the only accounting method allowed by law for external reporting, since it complies to the International Financial Reporting Standards (IFRS). The IFRS includes standards for financial statements for listed companies in the European Union (Bureau Kees Horden, n.d.). For unlisted companies in the Netherlands, the Dutch Generally Accepted Accounting Principles (GAAP) is applied. The Dutch GAAP also requires companies to apply absorption costing for external reporting.

The classification of fixed manufacturing overhead in absorption costing differs from the application in variable costing. As explained in Section 4.2.1.1, product costs include direct material costs, direct labour costs and manufacturing overhead costs. Manufacturing overhead costs can be divided into variable manufacturing overhead and fixed manufacturing overhead. In absorption costing, fixed manufacturing overhead costs are classified as product costs. In variable costing, fixed manufacturing overhead costs are classified as period costs. But what does this mean for the income statement?

The term cost of goods sold is often used in financial reporting, although it is mostly applied in absorption costing. It refers to the direct costs incurred by the production of the products sold by a company. Table 8 shows the calculation method for the cost of goods sold for retailers (Brealey et al., 2017).

Beginning inventory
Purchases (+)
Ending inventory (-)
Cost of goods sold

Table 8: Cost of goods sold calculation method for retailers.

In a manufacturing company, products are made from raw materials and are not sold in the same or a similar state as when they were purchased. Table 9 shows the calculation method for the cost of goods sold for a manufacturing company.

Beginning value finished goods inventory
Cost of goods manufactured (+)
Finished goods available for sale
Ending value finished goods inventory (-)
Cost of goods sold

Table 9: Cost of goods sold calculation method for manufacturing companies.

Table 9 includes the term ‘cost of goods manufactured’. The cost of goods manufactured is the total cost incurred with manufacturing products and transferring them into goods ready for sale, also known as finished goods (Hilton, 2011). Table 10 shows the calculation method for the cost of goods manufactured.

Direct materials used
Direct labour incurred (+)
Manufacturing overhead (+)
Beginning value work-in-process inventory (+)
Ending value work-in-process inventory (-)
Cost of goods manufactured

Table 10: Cost of goods manufactured calculation method for a manufacturing company.

In variable costing, fixed manufacturing overhead is not part of the product cost (Hilton, 2011). Instead, the total fixed manufacturing overhead is subtracted from the contribution margin, as shown in Table 12. Table 11 shows a simplified format of the income statement if absorption costing is applied. In absorption costing, on the other hand, fixed manufacturing overhead costs are allocated to the products manufactured and are included in the cost of goods manufactured, as shown in Table 11. So, if a company produces more products than a previous period, but sells the same number of products, the fixed manufacturing overhead costs are allocated to more products, resulting in a lower cost of goods sold and a higher net income if absorption costing is applied (Hilton, 2011). In variable costing, the fixed manufacturing overhead does not depend on the number of products manufactured, so the net income does not change if production increases and the number of sales remains the same. Since absorption costing is required for external reporting, a company producing more than it sells can appear more profitable than it actually is. So, the use of absorption costing creates an incentive for managers to increase production to appear more profitable. This can result in less accurate information about the actual financial condition of the company. So, variable costing can offer a more accurate method for internal financial reporting.

Absorption Costing	
Sales revenue	# of units sold * unit sales price
<i>Cost of goods sold (-)</i>	See Table 9
Gross result	
<i>Non-manufacturing overhead (-)</i>	
Net result	

Table 11: Simplified income statement applying absorption costing.

Variable Costing	
Sales revenue	# of units sold * unit sales price
<i>Variable product costs (-)</i>	# of units sold * unit variable product cost
Variable margin	
<i>Variable non-manufacturing overhead (-)</i>	
Contribution margin	
<i>Fixed manufacturing overhead (-)</i>	
<i>Fixed non-manufacturing overhead (-)</i>	
Net result	

Table 12: Simplified income statement applying variable costing.

Variable costing enables a company to perform a cost-volume-profit (CVP) analysis (Hilton, 2011). This type of analysis looks at the impact of varying levels of costs and sales volume on operating profit. By applying a CVP analysis, also known as break-even analysis, a company can compute its break-even point, the point where total revenue equals total cost, for different sales volumes and cost structures. Furthermore, variable costing provides more insight into the variable costs incurred with business operations.

Appendix G includes numerical examples if absorption costing and variable costing are applied. Input values for two months are used and equal for both months, except for the number of products produced in the second month, which is doubled compared to the first month. This leads to a higher net income if absorption costing is applied, making the company to appear more profitable, even though the company did not sell more products nor cut on costs. So, by applying absorption costing, a company can appear more profitable if it produces more products, which is misleading.

4.2.1.4 Activity-Based Cost Control

Activity-based costing (ABC) can be used for cost control as well. An ABC system incorporates all overhead costs into the product cost, meaning the cost of goods sold has a relatively higher value compared to absorption costing and variable costing systems (Hilton, 2011). Table 13 shows a simplified income statement if ABC is applied. For computing the net income, the sum of the unallocated costs is subtracted from the product margin. The sum of unallocated costs is usually relatively low, since most costs are incorporated into the product cost (Hilton, 2011).

Activity-Based Costing	
Sales revenue	# of units sold * unit sales price
<i>Total allocated costs (-)</i>	# of units sold * unit product cost
Product margin	
<i>Unallocated costs (-)</i>	
Net result	

Table 13: Simplified income statement applying activity-based costing.

Activity-based costing provides a more accurate allocation of all overhead costs incurred by the operations of a company. This way, the company gains insight into its indirect costs, enabling the

managers to make better informed decisions. Moreover, if ABC is performed well and overhead costs do not vary much, more consistent profit levels can be achieved.

4.2.1.5 Throughput Accounting

Throughput accounting, also known as super-variable costing, is an accounting system treating all expenses as period costs, except for direct material costs (Hilton, 2011). It expenses these period costs in the period in which they are incurred. Table 14 shows a simplified income statement if throughput accounting is applied.

Throughput Accounting	
Sales revenue	# of units sold * unit sales price
<u>Super-variable product costs (-)</u>	# of units sold * direct materials costs per unit
Throughput contribution margin	
<u>Period costs (-)</u>	
Net result	

Table 14: Simplified income statement applying throughput accounting.

Throughput accounting only treats unit-level costs as manufacturing costs. Unit-level costs are incurred every time a unit of a product is manufactured and are not incurred if another unit is not manufactured (Hilton, 2011). Direct labour costs are based on time units, since hourly wages are used. This means that direct labour costs are not incurred with every unit manufactured. Direct material costs, on the other hand, are incurred if a product is manufactured, meaning these are unit-level costs. So, the cost of goods sold is computed by multiplying the costs of direct materials per unit manufactured with the number of units sold. The operating expenses account includes direct labour costs, manufacturing overhead costs and non-manufacturing costs. This accounting system is seen as more accurate than other costing methods, since it tackles the incentive to decrease the average cost per unit by manufacturing more units (Hilton, 2011).

Throughput accounting is often used in combination with the Theory of Constraints (TOC) for accurately analysing the profitability of individual product types (Hilton, 2011). The TOC is a methodology identifying constraints in a production line (Slack et al., 2013). A constraint, also called bottleneck, is the main factor limiting the performance of a production facility. In throughput accounting, the time spent by each product at the constraint is monitored. Then, the unit throughput margin is divided by the time at the constraint, resulting in the throughput per time unit (Davico, 2020). This measures assesses the profitability of products more accurately by incorporating the throughput at the constraint of the production line.

Table 15 summarises the advantages and disadvantages of the four reporting methods discussed.

Financial Reporting Method	Advantages	Disadvantages
Absorption Costing	Easy to implement and eases comparison of results. Also the only method allowed for external reporting.	Creates incentive for managers to increase production to appear more profitable.
Variable Costing	Provides insight into the variable costs and enables managers to perform cost-volume-profit analyses.	More difficult to implement than absorption costing. Requires detailed knowledge about overhead costs.
Activity-Based Costing	Provides better insight into the indirect costs of the company.	Difficult to implement. Requires detailed knowledge about overhead costs quickly.

Throughput Accounting	More accurate assessment of profitability. Also eases the process of identifying bottlenecks.	Difficult to implement. Mostly applicable when throughput is easy to monitor.
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Table 15: Advantages and disadvantages of four financial reporting methods.

4.2.2 Cost Variance Analysis

Next to external financial reporting, a company can report its financial performance internally. For this, more freedom is available, since the company does not have to follow the regulations of the IFRS or GAAP. As discussed in Section 4.2.1, the financial reporting methods can be used for internal reporting as well. Next to this, a company can focus on other financial performance indicators by using different methods for performance measurement. At Company X, the performance evaluation tool provides insight into the financial performance of the company weekly. The main goal of my research is to enable the managers to accurately perform cost variance analyses and thereby create the possibility to focus on reducing the cost variance. Currently, Company X does not analyse cost variances. A cost variance provides useful information about the actual financial performance of individual product types. But how can the cost variance be measured?

As explained in Section 2.2, a cost variance is the difference between the standard cost and the actual cost (Hilton, 2011). It is generally preferred to have a low cost variance. A low cost variance usually indicates that the actual cost is equal to or lower than the standard cost. If a high cost variance is observed, the managers should quickly react and cut on costs if possible. The cost variance principle seems simple. However, at a company producing a wide variety of product types, it can be difficult to measure and compute cost variances. At Company X, the accounting tools currently used are unable to provide knowledge about the cost variance of each product. Instead, general financial results are generated and not compared with standard results. A cost variance analysis provides the managers useful insights into the actual financial performance of individual products.

But what is a favourable cost variance? And how can this be achieved? A favourable cost variance is observed if the amount of costs actually incurred is close to the budgeted amount. It is unfavourable if the actual amount is significantly lower than the budgeted amount, because this would mean the cost price and selling price are probably too high, meaning the company could miss out on sales. A high cost variance would indicate that the company is incurring more costs than expected, possibly resulting in lower profits.

To achieve a favourable cost variance, two important aspects should be kept in mind. First, the company should ensure a realistic budget is set. This requires accurate cost ascertainment. For Company X, this means that the price calculation tool should accurately estimate the to be incurred costs for manufacturing a specific product. Second, the costs actually incurred should be accurately monitored and managed. This requires reliable cost control tools, such as a dashboard presenting KPIs and general financial results. At Company X, the two performance evaluation tools do not enable the managers to perform cost variance analyses. The actual cost for each product type is not monitored and the actual financial results are not compared with standard results. Several interventions in the current accounting tools should enable the company to perform cost variance analyses, such that the managers gain insight into the actual cost structure of the production facility and the financial performance of the products. This can include the implementation of a new product costing method and cost control method. In Chapter 5, I discuss which cost accounting methods are the most suitable to implement at Company X such that the accuracy of the cost accounting process increases. Additionally, I elaborate on possible interventions enabling the managers to perform cost variance analyses.

Chapter 5: Selecting Methods for Increasing Accuracy

In Chapter 4, I discussed several possible cost accounting methods to apply at Company X. In this chapter, I elaborate on the most suitable methods, meaning I discuss the pricing strategy, product costing method and financial reporting method I implemented in the new cost accounting tools. Furthermore, I discuss the most suitable measure for the cost variance. The methods selected should enable the managers of Company X to manage costs as accurately as possible, assess cost variances and contribute to continuous improvement. The implementation of these methods in the new tools is discussed in Chapter 6.

5.1 Cost Ascertainment

In Section 4.1, I elaborated on several cost ascertainment methods and pricing strategies. Cost ascertainment, also known as product costing, is about estimating the costs incurred with manufacturing and selling a product. Product costing and product pricing are closely related, as explained in Section 4.1.2, so this should be kept in mind if a company decides to implement a new product costing method or pricing strategy. In this section, I elaborate on the most suitable product costing method based on the most suitable pricing strategy such that accurate and reliable selling prices can be computed, ensuring all costs are covered and desired profits are realised. The pricing strategy should be selected before selecting a product costing method. If competition-based or value-based pricing is the most suitable pricing strategy, target costing should be applied. These pricing strategies set a limit for the cost price to achieve a certain level of profitability, meaning the company should stay under the target cost. If cost-plus pricing is the most suitable pricing strategy, traditional costing and activity-based costing become more relevant, since this pricing strategy requires an accurate estimation of the cost price before setting a selling price.

5.1.1 Pricing Strategy: Cost-Plus Pricing

As explained in Section 4.1.2.1, Company X currently applies the cost-plus pricing strategy by using fixed price contracts. This means that a fixed price is agreed upon before manufacturing starts. If a customer places an order, the managers make an estimation of the manufacturing cost to be incurred and explore the market for prices of competitors. Based on these findings, a profit mark-up is determined, usually 30% of the manufacturing cost price, and a selling price is set. In a fixed price contract, the risk associated with any cost increase lies with the seller. So, an accurate estimation of the manufacturing cost to be incurred is essential.

At Company X, products are manufactured based on customer needs. This means that the company manufactures several products with different specifications. So, for each product type, a different amount of resources is needed and a 'budget' is determined before manufacturing starts. This means that for each new product, a price calculation has to be made.

A company can either apply cost-plus pricing, competition-based pricing or value-based pricing, as discussed in Section 4.1.2. In competition-based pricing and value-based pricing, the company sets a price and needs to stay under this price in order to maintain profitability. These pricing strategies are usually associated with target costing, which is a product costing method that focusses on staying under a specific budget. This method is an interesting method for Company X, although there are some drawbacks. If competition-based pricing or value-based pricing is applied and thereby target costing as well, a company cannot differentiate itself from the competition with lower selling prices. Instead, the company focusses on delivering unique quality or service. This is not the main objective of Company X, since it is difficult to deliver unique quality with its business operations. The products are unique, specific and based on specifications provided by customers. Metal injection moulding does not offer that much variety in terms of product quality, so competitors offer comparable quality. Company X can mostly differentiate itself from competitors by providing lower prices. Cost-plus pricing motivates the managers of a company to cut on costs, since the cost price is a leading factor in the price calculation. A lower cost price enables a company to offer lower selling prices while keeping the profit mark-up the

same. Lower selling prices possibly result in more sales. A company applying cost-plus pricing should strive to become cost leader in the market to obtain market benefits. For this, accurate cost control and cost ascertainment are of high importance. Company X has the potential to become cost leader if it focusses on continuous improvement of these accounting processes.

5.1.2 Product Costing: Activity-Based Costing

As discussed in Section 4.1.1, several methods can be applied for product costing. To gain understanding of which methods are most frequently used at other manufacturing companies, I executed a systematic literature review. The findings are discussed in this section. Moreover, I discuss which costing method is the most appropriate for Company X and why. Appendix H provides a detailed explanation of the method applied for this systematic literature review.

A traditional costing system, such as variable costing or absorption costing, should be avoided. In these costing systems, all overhead costs are allocated to products using a general predetermined overhead rate, as explained in Section 4.1.1.1. These systems perform insufficiently in terms of accuracy. For example, if overhead is allocated by using the amount of labour hours as cost driver, more overhead costs are allocated to a product requiring relatively more labour hours for manufacturing. This is inaccurate, since it does not necessarily mean that a product requiring more labour hours has to cover more costs, especially if the overhead costs are not related to staff at all. At Company X, the fixed overhead costs form a large proportion of the monthly costs, meaning the overhead costs should be allocated as accurately as possible to ensure all costs are covered.

As explained in Section 5.1.1, target costing is an interesting costing method for Company X. However, if the company applies target costing, it is not able to differentiate itself from competition with lower prices, since selling prices are competition- or customer-based. Furthermore, target costing can create an incentive for the managers to opt for cheaper materials, staff, machines or external partners, possibly resulting in lower quality. Company X focusses on high quality, so target costing does not fit its business strategy. Besides, target costing ignores the actual capabilities of the production process of the company, meaning it could lead to unfeasible prices.

As discussed in Section 4.1.1.2, activity-based costing is focussed on allocating overhead costs to several activities within a company instead of directly assigning the costs to the product with a predetermined overhead rate. Kumar & Mahto (2013) state that the application of activity-based costing provides better insight into how a product is produced, how much time and resources are needed for each activity in the process and how much money is incurred by each activity. According to the results of this study, traditional costing can lead to inaccurate costing information, possibly resulting in ill-informed decisions by the managers. Tuncel et al. (2005) show that traditional costing leads to distortion of cost information. The authors concluded that activity-based costing is capable of tracking costs that seem to be untraceable if traditional costing is applied. Myers (2009) also observed in his field study that traditional costing can lead to product cost distortions and implies that this costing method is outdated. So, activity based costing seems to be more suitable for Company X. It provides more accurate cost ascertainment, eases the process of cost reduction and possibly increases competitiveness (Arora & Raju, 2018).

Activity-based costing has several applications. According to Turney (2008), activity-based costing is applied for, for example, profitability management, performance measurement, sustainability, human capital management and financial planning. Activity-based costing provides accurate information on actual product costs, estimated costs and new product development costs (Bharara & Lee, 1996). These data are useful for continuous improvement of a business unit. Several studies also suggest different variations of activity-based costing, such as time-driven activity-based costing. Time-driven activity-based costing is widely adopted by many companies. This method allocates overhead costs to departments instead of all individual activities (Öker & Adigüzel, 2010). As the name suggests, it merely focusses on processing times and connects these with the cost drivers chosen.

The implementation of activity-based costing can lead to some difficulties. Gunasekaran & Sarhadi (1998) studied several cases containing the analysis of the implementation process of activity-based costing at manufacturing companies. They concluded that successful implementation requires top management commitment, education and training for employees and incentives to motivate the employees in implementing activity-based costing. Once successfully implemented, the perceived benefits from implementing activity-based costing can be achieved. A case study by Arora & Raju (2018) shows that, once successfully implemented, there is no significant difference between perceived and actual benefits from implementing activity-based costing. So, successful implementation is key in maximising the effectiveness of activity-based costing. The managers of Company X should be fully committed and motivated, and should be familiar with the application of the method (Gunasekaran & Sarhadi, 1998).

Activity-based costing is the most suitable method to be implemented at Company X. Since the company applies cost-plus pricing, only traditional costing and activity-based costing are appropriate. Traditional costing, however, provides inaccurate and very arbitrary overhead allocation. Activity-based costing provides insight into the actual cost drivers of a product, enabling the company to compute a better-motivated overhead allocation. In Section 6.1.2.2, I discuss the application and implementation of activity-based costing at Company X.

5.2 Cost Control

Cost control mainly includes managing and monitoring costs. This includes financial reporting, which can be done for external and internal purposes. For internal reporting, cost variance analyses are very useful for assessing the financial performance of each product in production. Comparing standard results with actual results is very useful for companies in which cost ascertainment plays an important role.

In this section, I elaborate on the most suitable financial reporting method for computing general financial results at Company X. Furthermore, I discuss the most appropriate cost variance measure to be implemented in the new performance evaluation tool, such that cost variances can be accurately tracked and monitored.

5.2.1 Financial Reporting: Absorption Costing

As discussed in Section 4.2.1, financial reporting can be done for external and internal purposes. Absorption costing is the only method allowed for external reporting. Company X uses absorption costing for internal reporting as well. A big drawback of absorption costing is that it creates an incentive for managers to increase production, making the company to appear more profitable than it actually is. For example, if sales revenue is equal to the previous month, a company can still appear to be more profitable if more products are produced during the current month than the previous month. This is not a problem for Company X. The company manufactures based on fixed contracts, meaning products are manufactured and delivered according to an agreement. A high sales revenue during a specific month does not necessarily mean the company did a good job, since the date of delivery depends on planning. If many products are planned to be delivered during a specific month, the company can appear to be profitable during that month. However, during this period, productivity of the production facility can be low, indicating the company does not perform that well, although it appears to be profitable on the financial statements. So, results obtained from absorption costing should not be a leading factor in decision-making, since the profitability observed on the financial statements does not directly imply sufficient performances. However, for Company X, absorption costing is an appropriate financial reporting method, since results can easily be compared with past results and it is easy to implement.

Variable costing is more difficult to implement than absorption costing. It requires accurate knowledge about the overhead costs, such that fixed overhead and variable overhead can be separated on financial statements. Furthermore, cost-volume-profit (CVP) analyses are inapplicable to Company X, since sales volumes are fixed and agreed upon before manufacturing. So, variable costing is not recommendable for implementation at Company X.

Activity-based cost control incorporates all overhead costs into the product cost, meaning it focusses on covering all costs incurred by the company. In financial reporting, activity-based cost control can be useful if overhead costs do not vary that much. At Company X, some overhead costs, such as indirect labour costs and machine maintenance, can vary much and mostly depend on the productivity of the production facility. In this case, activity-based cost control could generate inaccurate results, since overhead allocation is often very arbitrary. Furthermore, the current way of working at Company X does not enable the implementation of activity-based costing for cost control. For product costing, activity-based costing is really useful and provides a better estimate of the product costs. Activity-based cost control, however, lacks effectiveness and is not worth the cost of implementation.

Throughput accounting is an accounting system opposing other cost accounting methods, treating only direct material costs as product costs. It focusses on identifying the profitability of products involving the constraints of production, which are bottlenecks of a production process. This accounting system tries to eliminate the perceived importance of budgets and intends to deliver more accurate information about the profitability of products. At Company X, however, budgeting is important, since its manufacturing operations are based on fixed contracts involving predetermined selling prices. Furthermore, its production process does not involve complicated machinery nor is it focussed on speed, so bottlenecks do not arise that often. So, throughput accounting is not suitable for implementation at Company X. However, if bottlenecks arise due to higher complexity of the production process, throughput accounting can be considered.

So, for reporting general financial results internally, absorption costing is the way to go for Company X. However, just applying absorption costing is not enough for monitoring and assessing the financial condition of the company. Additional performance indicators, such as cost variances, should be implemented in the accounting tools to fully assess the performance of the production process. Since accurate cost ascertainment is important for Company X, actual and standard results should be compared. This way, more useful information is retrieved, ensuring the managers make well-informed decisions.

5.2.2 Cost Variance Analysis: Connecting Cost Ascertainment and Cost Control

A cost variance analysis can include several measures. A simple measure is the cost variance itself. The cost variance is the difference between the budgeted or expected cost, also known as planned value or budgeted cost of work scheduled (BCWS) (Anbari, 2003), and the actual cost. This can be measured at the end of a project and during a project. A project at Company X implies a product order, so a project is the process of manufacturing the number of products agreed upon in the order. If the cost variance is measured during a project, the expected cost of the work performed during a specific period of the project is known as the earned value or budgeted cost of work performed (BCWP) (Anbari, 2003) instead of the BCWS. The BCWP is equal to the amount of costs expected to have been incurred during a specific period. The cost variance during a specific period of a project is calculated by applying Formula 5.1.

$$\text{Cost Variance} = \text{BCWP} - \text{Actual Cost}. \quad 5.1$$

Formula 5.1 computes the actual monetary variance of costs incurred by a specific project. If cost variances of different projects are compared, this formula does not comply. Projects incurring relatively high costs usually have relatively large cost variances, though the proportional difference between the BCWP and actual cost might be lower than projects incurring lower costs. So, for comparing cost variances with different projects, the cost variance should be calculated in terms of percentage by applying Formula 5.2 (Anbari, 2003). This formula computes the variance relative to the financial size of the project or order.

$$\text{Cost Variance \%} = \frac{\text{Cost Variance}}{\text{BCWP}}. \quad 5.2$$

A positive cost variance indicates the project is currently performing below budget, meaning the actual cost is lower than the BCWP. A favourable cost variance should be around 0%, as explained in Section 4.2.2. A cost variance around 0% indicates the actual cost is approximately equal to the BCWP. A variance higher than 0% indicates the company performs below budget, possibly indicating the cost price was set too high. A cost variance lower than 0% indicates the actual cost is higher than the BCWP, possibly indicating the cost price was set too low and/or higher costs are incurred than expected. The managers should set a target for the cost variance. A cost variance between 10% and -10% is a recommendable target.

To enable Company X to monitor cost variances, the performance evaluation tool should be able to compute both the actual cost and the BCWP for each product type. For the BCWP, standard costing should be used. This costing method makes use of standard values, meaning direct manufacturing costs and manufacturing overhead are calculated based on predetermined rates. This requires input from the price calculation tool, such that an accurate estimation of the BCWP can be made. This includes the standard costs per unit for each step of the production process. By multiplying the standard unit cost with the number of products produced at a certain step, the BCWP of these products produced can be computed. Currently, the standard costs are not incorporated into the performance evaluation tool of Company X, meaning the cost variance cannot be computed.

Actual costs should be accurately estimated in order to compute cost variances. For Company X, the manufacturing cost and its components are the most important to analyse in a cost variance analysis. The product cost, including non-manufacturing overhead costs, depends on an arbitrary overhead allocation, meaning it would not be that useful to incorporate non-manufacturing overhead costs in the cost variance analysis. The manufacturing cost mostly consists of variable costs, making it easier and more reliable to compare the actual manufacturing cost with the standard cost. Furthermore, analysing the cost variance of manufacturing costs could provide more insight into the performance of the several parts of the production process, since the actual manufacturing cost can be computed for each part easily.

The actual manufacturing cost includes the direct material costs, direct labour costs and manufacturing overhead costs actually incurred. Currently, the direct material costs are not tracked at Company X, meaning an intervention in the production process and way of working of the operators is required to monitor the actual direct material costs accurately. Direct labour costs are tracked in the performance evaluation tool by using the personnel data inserted into the tool. Manufacturing overhead costs are difficult to track, since the machine hour rates are based on predetermined rates and incorporate multiple overhead cost items. Computing the actual manufacturing overhead would take much time, since the incorporated overhead costs are mainly based on quotations, taking more time to find out what the amount of costs actually incurred was. So, actual costing is inapplicable for computing the actual cost. Normal costing, on the other hand, is the most suitable, so direct costs should be computed based on actual rates, and manufacturing overhead should be computed by using predetermined rates.

5.3 Summary

In this chapter, I discussed the most suitable cost accounting methods to be implemented at Company X. The price calculation tool should incorporate the cost-plus pricing strategy. Furthermore, it should apply activity-based costing to allocate non-manufacturing overhead costs, providing a well-motivated allocation. In the performance evaluation tool, absorption costing should be applied for reporting general financial results, such as the net result. This method is easy to implement and enables easy comparison of current results with previous results. In addition, the performance evaluation tool should enable the managers of the company to perform cost variance analyses. For this, the tool should incorporate standard costs computed in the price calculation tool. This way, actual results can be compared with expected results more easily.

Chapter 6: Developing New Cost Accounting Tools

In this chapter, I elaborate on the cost accounting tools I developed in Microsoft Excel for Company X. This includes a price calculation tool for cost ascertainment and a performance evaluation tool for cost control. The tools are designed to enable the managers of the company to perform cost variance analyses, and manage and monitor manufacturing costs more accurately.

6.1 Price Calculation Tool

The price calculation tool is used for cost ascertainment. With this tool, the user, the managing director, should be able to compute a cost price and selling price for a product by entering several product-specific input values. It should be clear which values can be changed in the tool. In general, the managers of Company X want the tool to be user-friendly, such that it can be easily understood and used by successors and other employees. Furthermore, the tool should generate output data to be used in the performance evaluation tool. These data include standard costs, enabling the user to perform cost variance analyses by comparing the costs actually incurred with these standard costs.

In this section, I explain how the manufacturing cost price is computed in the new tool. The manufacturing cost price is used as standard cost in the performance evaluation tool, since it is quite easy to estimate and cannot be affected by inaccurate non-manufacturing overhead allocation. Furthermore, I elaborate on the overhead allocation method I applied and its connection with the performance evaluation tool. In addition, I discuss the pricing strategy to be applied and the output generated for cost variance analysis.

6.1.1 Manufacturing Cost

The cost of manufacturing a product includes direct material costs (DM), direct labour costs (DL) and manufacturing overhead costs (MOH). In the price calculation tool, the manufacturing cost price can be estimated accurately. The managers of Company X have enough knowledge about the production process such that the required amount of materials, labour hours and machine hours can be estimated easily with the tool. This computation requires some general input values concerning the production process and the specific product. The production process is divided into several steps and an estimation is made for the to be incurred costs for each step. The sum of the costs incurred with all steps equals the manufacturing cost. Figure 3 shows the steps of the production process as used in the new price calculation tool. Each step is broken down into multiple activities. Each activity involves one type of cost, such as direct materials, direct labour or manufacturing overhead. The value of these cost types is calculated based on product properties, process properties and order information, which are inputs of the tool.

6.1.1.1 Order Information and Product Properties

The annual order size is used as input value. Based on this order size, the user determines the number of batches for metal injection moulding, which is also an input of the tool. This number is used for estimating the costs incurred by machine setups. All computations of the tool are based on annual numbers, so the annual order size should be used. Product properties are inputs as well. This includes the type of material, product dimensions and the desired product weight. These properties are mainly used when calculating batch sizes and material costs.

6.1.1.2 Process Properties

Many properties of the production process are used for computing the manufacturing cost and depend on the product properties. For estimating the costs to be incurred with metal injection moulding, mould properties are used as inputs to estimate the number of machine hours needed. These properties include the number of cavities of the mould and the estimated time per injection. With this information, the number of products to be produced per machine hour can be estimated. The total number of machine hours needed is based on the number of units to be produced as well. The number of units to be produced is not equal to the order size, since product failure rates should be incorporated into the calculations.

Product failure rates are inputs as well. For this, the production process is divided into three parts. For each part, a product failure rate is entered by the user, since this is often product-specific. For example, if an overall product failure of 5% is expected with an order of 1000 units, a minimum of 1053 units ($1000/0.95$) has to be produced in order to reach the production target of 1000 units. By dividing the number of products to be produced by the number of products able to be produced per machine hour, the total number of machine hours needed is computed. Once the required number of machine hours is known, an hourly rate is applied for allocating manufacturing overhead costs, including depreciation costs, machine maintenance costs and gas and electricity costs. The hourly rates for machine hours are machine-specific and entered in the tool by the user.

For the cost estimations for debinding, sintering and post-processing, several input values are required. These input values mainly include stack dimensions, stacking times and processing times. These values are product-specific, so this requires input from the user. Next to the costs incurred by internal processes, products often need external processing too. Again, this requires input by the user, since the types of external processing required are product-specific as well.

[this information is removed due to confidentiality]

Figure 3: Components of new price calculation tool.

6.1.2 Non-Manufacturing Overhead Allocation

The products a company sells have to cover all costs incurred by being and staying in business. This includes costs incurred by manufacturing, known as manufacturing costs, and costs incurred by selling, general and administrative operations, also known as SG&A, operating expenses or non-manufacturing overhead. In the current price calculation tool of Company X, non-manufacturing overhead is not allocated to individual products. Instead, a large profit margin is used to cover these costs. As discussed in Section 5.1.2, activity-based costing should be used for allocating overhead to ensure all costs are covered. By adding a profit mark-up according to the cost-plus pricing strategy, the new tool can compute a selling price.

Figure 5 shows a numerical example of a non-manufacturing overhead allocation for a specific product in the price calculation tool I developed. Three input values are required, namely the yearly non-manufacturing overhead costs to allocate, the average capacity utilisation of the metal injection moulding machines and the average capacity utilisation of the sintering machines.

6.1.2.1 Estimating the to be Allocated Non-Manufacturing Overhead Costs

The amount of annual overhead costs to allocate is based on recent results and should be estimated by the managers of the company. In collaboration with the production manager, I estimated the yearly non-manufacturing overhead to be equal to €500,000 [this number is fictional due to confidentiality]. This estimation is based on the estimated amount of monthly overhead costs. The estimated monthly overhead costs are shown in Appendix I, including a division between several cost items. We concluded that the total monthly overhead equals €50,000, consisting of €10,000 of manufacturing overhead and €40,000 of non-manufacturing overhead [these numbers are fictional due to confidentiality]. This division of overhead costs is based on two categories of business activities, namely manufacturing activities and other activities, such as management and administration. The category of other activities is hard to divide into separate activities, since the contribution of these activities to the overall turnover is significantly lower than the contribution of the manufacturing activities. Furthermore, Company X does not have multiple departments, so the managers are responsible for multiple different tasks, such as sales and administration.

In the current tool, machine hour rates cover the manufacturing overhead costs in the cost price. For the new tool, I adjusted the rates such that €10,000 of manufacturing overhead costs is really covered, so these costs do not have to be allocated anymore. This leaves €40,000 of monthly overhead costs to allocate, which equals €500,000 of annual overhead costs.

6.1.2.2 Allocating Non-Manufacturing Overhead Based on Machine Capacity Utilisation

Activity-based costing can be applied in several ways. One of which is known as time-driven activity-based costing (TDABC) (Öker & Adigüzel, 2010). TDABC is mostly useful if a traceable amount of time is spent on the activities. The cycle times for each product at the metal injection moulding machines of Company X are really low and difficult to track, making TDABC difficult to implement. Besides, not many activities at the company are time-driven or require varying amounts of time, making the selection of possible cost drivers limited. For this reason, I looked into the application of traditional activity-based costing instead of TDABC.

The first stage of activity-based costing comprises the selection of activities. When observing the current price calculation tool, I concluded that most costs are incurred by the metal injection moulding process and the sintering process. At other companies, overhead costs are often incurred by activities from other departments than the manufacturing department, such as the sales department or customer service. Company X does not have such departments. The overhead costs are indirect costs, but if production increases, most overhead costs tend to increase as well. So, as activity cost pools, I divided the production process into two pools: metal injection moulding and sintering. Much information is known about these processes, such as production rates and processing times, making it easier to work with. Furthermore, these processes incur a large proportion of the total amount of costs incurred by manufacturing a product, increasing the influence of these processes on the profitability of the company.

The components of the non-manufacturing overhead are difficult to assign to a specific business operation or product type. For example, if costs are incurred by customer service, one can use the number of customers served as cost driver for this cost pool. However, the non-manufacturing overhead cost items of Company X are really general and cannot be assigned to a specific activity within the company. Furthermore, the company produces many different products, so the type of products and number of products produced in a specific period of time are always different than other periods, resulting in difficulties when assigning overhead costs to a specific type of product. The company is mainly focussing on its manufacturing activities, so I searched for a cost driver within the production process. It is reasonable to assign more costs to a product requiring relatively more time, resources or capacity for manufacturing. However, each product has different properties and involves different cycle times, so comparing products based on resource consumption or time consumption alone would be unreasonable. The machine capacity utilisation, however, tells more about the overall time and workload required for the manufacturing of a specific product. The capacity utilisation of machines is the number of machine hours or runs used in proportion to the total available number of machine hours or runs. If more capacity is needed for a specific product, the product requires, in general, more time, resources and equipment. So, I developed an overhead allocation method integrating machine capacity utilisation.

In the new price calculation tool, machine capacity utilisation is used as activity-based cost driver for both activity cost pools. The capacity utilisations of the metal injection moulding machines and sintering machines are exponentially weighted moving averages of recent results. These averages are computed in the performance evaluation tool I developed. These computations are discussed in Section 6.2.3.2. The new price calculation tool uses the machine capacity utilisation for computing the daily average number of machines in use and the annual capacity available. In the example of Figure 5, an average machine capacity utilisation of 56% at the metal injection moulding machines is used as input value for the price calculation of the specific product. This input value is based on the exponentially weighted moving average computed in the new performance evaluation tool. A machine capacity utilisation of 56% means that, on average, 56% of the total capacity available is in use, which equals approximately five machines of the nine machines available. The annual average capacity of metal injection moulding machine hours is computed by applying Formula 6.1.

$$\begin{aligned} \text{Annual Average Capacity MIM Machine Hours} = & \text{Daily Average \# Machines in Use} \times \\ & \# \text{ Machine Hours Available per Day per Machine} \times \# \text{ Working Days in a Year.} \end{aligned} \quad 6.1$$

By multiplying the daily average number of machines in use, which equals approximately five machines in the example of Figure 5, by the number of available machine hours per day, which is assumed to be 7 hours, and by the number of working days in 1 year, which is assumed to be 255 days, an annual capacity of 8,996 metal injection moulding machine hours is computed. For the sintering machines, the new tool applies Formula 6.2.

$$\begin{aligned} \text{Annual Average Capacity Sintering Runs} = & \text{Daily Average \# Sintering Runs} \times \\ & \# \text{ Working Days in a Year.} \end{aligned} \quad 6.2$$

A machine time of 7 hours per machine on 1 day does not happen often. However, for computing the machine utilisations, a machine time of 7 hours as daily capacity is used in the performance evaluation tool as well. Since the operators do not track the number of machines hours used, the daily average capacity of effective machine hours cannot be computed. So, for computing the annual average capacity, the tool incorporates a daily capacity of 7 machine hours per machine. Because Company X does not count and check its products after debinding, debinding and sintering are considered together as one step of the production process in this calculation. Furthermore, a product requiring relatively more sintering runs also requires relatively more debinding runs, since similar batch sizes are used.

Next, the overhead costs have to be assigned to the metal injection moulding and sintering activities, since these are the activity cost pools. A product using 3% of the annual capacity of metal injection moulding machines hours does not necessarily use 3% of the annual capacity of sintering runs, so the division of the total amount of overhead costs cannot be assumed to be 50% against 50%. I discussed this issue with the production manager, who is also the main user of the new tool. We concluded that the metal injection moulding activities should cover 75% of the total overhead and the sintering activities 25%. These percentages are based on the cost prices of twenty products, as shown in Appendix Q. On average, 75% of the unit cost price of a sintered product, internally known as white product, is incurred by metal injection moulding and 25% by debinding and sintering. Therefore, I used these percentages for each cost pool. In the example of Figure 4, this means that 75% of the €500,000 of non-manufacturing overhead is applied to the metal injection moulding cost pool, which equals €375,000, and 25% of the €500,000 of non-manufacturing overhead is applied to the sintering cost pool, which equals €125,000, as shown in Figure 5.

For allocating the overhead costs to the specific product, the product-specific capacity occupation is computed. The capacity occupation is calculated with the use of Formula 6.3.

$$\text{Machine Capacity Occupation} = \frac{\# \text{ Machine Hours or Runs Needed}}{\text{Annual Average Capacity Machine Hours or Runs}}. \quad 6.3$$

The machine capacity occupation is the number of machine hours or runs needed in proportion to the total average number of machine hours or runs available. The price calculation of the example of Figure 4 computed a total of 364 metal injection moulding machine hours needed. Figure 4 shows the input values and steps of this computation. Based on the number of cavities in the mould and the time per injection, the estimated number of products to be produced per machine hour equals 480 in the example. Based on the product failure rates of the several steps of the production process, 174,953 units have to be produced to ensure the order size of 150,000 of the example product is met. So, by dividing the production target of 174,953 units by the theoretical production of 480 units per machine hour, a total of 364 machine hours needed is computed.

[this information is removed due to confidentiality]

Figure 4: Computation of number of metal injection moulding machine hours needed for production.

[this information is removed due to confidentiality]

Figure 5: Example of non-manufacturing overhead allocation in new price calculation tool.

The 364 machine hours needed are approximately 4% of the annual average capacity of 8,996 machine hours, as shown in Figure 5. So, 4% of the machine capacity is used for production of the specific product. Since the product requires 4% of the annual capacity, 4% of the annual overhead applied to the metal injection moulding cost pool has to be covered by the specific product. So, 4% of €375,000, which was allocated to the metal injection moulding activities, yields €15,000. The same is done for sintering, yielding €13,750 of overhead applied. The sum of these, €28,750, is added to the manufacturing cost, resulting in the total amount of costs incurred by manufacturing and delivering the product.

The use of the annual average capacity for overhead allocation increases the accuracy of the tool. If the normal capacity is used, so by using nine machines as daily capacity instead of five, the overhead costs would not be fully covered if the capacity is not fully used. Appendix P includes the price calculations of three products, together requiring the total capacity available. Table 39 shows that the calculations cover all overhead costs.

So, by using recent performances on machine capacity utilisation, the tool uses up-to-date information, resulting in more accurate estimations. Furthermore, this overhead allocation encourages the company to maximise its machine capacity utilisation. This can be done by increasing productivity, or by selling unnecessary machines. If the machine capacity utilisation is relatively high, the amount of overhead costs to be allocated to new products is relatively low, resulting in relatively lower cost prices. Lower cost prices enable the managers to reduce selling prices to possibly increase sales, or to increase profit margins while using the same selling prices.

6.1.3 Selling Price

As discussed in Section 5.1.1, cost-plus pricing is the most suitable pricing strategy to be applied at Company X. In cost-plus pricing, a profit mark-up is added to the cost price. In the new price calculation tool, the user is able to add a product-specific profit mark-up to set a selling price. Company X strives for a profit margin of X%, so a mark-up of X% should be used in the price calculation tool. The mark-up can be modified according to market changes and marketing strategies.

6.1.4 Output

To enable the managers of Company X to perform cost variance analyses, data from the price calculation tool are required. The tool computes the expected costs to be incurred, also called standard costs. These standard costs are required for computing the BCWP, as explained in Section 5.2.2. For each new product, the following data are copied from the price calculation tool to the new performance evaluation tool:

- Standard product value after each step of the production process.
- Selling price of the product.
- Standard manufacturing costs per unit per step of the production process, containing a division between direct material costs, direct labour costs and manufacturing overhead costs.
- Standard number of products produced per metal injection moulding machine hour.
- Standard number of products produced per sintering run.
- Standard product failure at metal injection moulding machines.

In Section 6.2, I elaborate on the use of these data in the new performance evaluation tool.

6.2 Performance Evaluation Tool

The performance evaluation tool is mainly used for cost control purposes. The main goal of this tool is to provide an analysis of the financial results realised in a specific period quickly and accurately. Results generated in this tool should facilitate the decision-making processes of the managers and ensure they

are well-informed. A performance evaluation tool should include KPIs to assess the most important results. For Company X, the main KPI to analyse is the cost variance, which is not included in the tools currently used.

In this section, I elaborate on the performance evaluation tool I developed for Company X. First, I discuss the inputs of the tool. Next, I discuss the underlying calculations of the tool in detail. These calculations are used to compute general financial results, cost variances, performances on other KPIs and inputs for the price calculation tool. The dashboard of the tool provides an overview of this information. The information provided is discussed profoundly in this section. Furthermore, I elaborate on the additional features of the tool enabling the user to easily compare observed results with previous results.

6.2.1 Input

The performance evaluation tool and price calculation tool are connected to ensure accurate computations and to enable the managers to perform cost variance analyses. Furthermore, personnel and inventory data are used as inputs for the tool, since they are essential for the calculations. The personnel data include the number of labour hours made by each employee in a specific period of time. Additionally, the labour hours are connected to product types, such that the total number of hours spent on a specific product can be computed. The inventory data are essential for most calculations in the tool, since they include the number of units produced at each step of the production process and the corresponding date. The current performance evaluation tool uses personnel and inventory data as inputs as well, and retrieves these data from the ERP system.

In the new performance evaluation tool, I added a sheet containing information about the overhead costs of the company. This information includes all types of overhead costs incurred by all business operations. Appendix I shows an overview of these overhead costs. The user is able to change the amounts, such that the data used for computing the net result are up-to-date. Furthermore, I added a sheet for computing the amount of direct material costs actually incurred, which I discuss in Section 6.2.2.1.

To enable the managers to perform cost variance analyses, the input data mentioned in Section 6.1.4 are inserted into the new performance evaluation tool. For some calculations of the tool, additional input by the user is required. Figure 6 shows the input data required. It includes the hourly wages of the operators. The values of these parameters are equal to the ones used in the price calculation tool and are used for estimating the direct labour costs actually incurred. Additionally, the metal injection moulding machine hour rate and sintering run rate are required. The values shown in Figure 6 are used in the price calculation tool as well, but can be modified if necessary. The tool uses these rates for estimating the manufacturing overhead costs actually incurred. For computing this amount for the sintering process, the sintering runs actually used should be monitored and entered in the dashboard. Furthermore, the number of metal injection moulding machines and sintering machines can be changed if capacity is expanded.

[this information is removed due to confidentiality]

Figure 6: General input for new performance evaluation tool.

In the new tool, the number of working days in the specific period is required for computing several values of some performance indicators, such as the average number of products produced per day and machine capacity utilisation. For this, the tool automatically calculates the number of working days when the personnel data are inserted, since they include the dates of the labour hours. However, possible holidays are excluded, meaning input is required to compute the number of working days in a specific period precisely. So, by subtracting the number of holidays from the number of working days generated by Excel, the actual number of working days is computed.

The general input shown in Figure 6 includes a drop-down list for the parameter ‘Period To Evaluate’. The user can pick one of three options: ‘1 Week’, ‘1 Month’ or ‘Other’. The selection should be based on the financial period of the personnel and inventory data inserted. If one wants to perform an evaluation of one week, the user should insert these data from one week and select ‘1 Week’ in the drop-down menu. Then, the results generated in the dashboard are copied to another sheet, called ‘KPI History’. I elaborate on the content of this sheet in Section 6.2.4.

6.2.2 Cost Variance Analysis

The main purpose of the performance evaluation tool is to provide an overview of cost variances quickly. As explained in Section 4.2.2, the cost variance is the difference between the budgeted cost of work performed (BCWP) and the actual cost. At Company X, the manufacturing cost is the most interesting type of cost to analyse. To compute the cost variance by applying Formula 5.2, the tool should be able to compute the BCWP and the actual cost.

6.2.2.1 BCWP and Actual Cost

The BCWP is the total amount of costs expected to be incurred in the current stage of production, meaning it depends on the standard costs and the number of products produced so far. The standard unit costs are copied from the price calculation tool, as explained in Section 6.1.4. By multiplying standard unit costs with the number of products actually produced, the BCWP is computed. The actual cost is the manufacturing cost actually incurred and is estimated in the calculation sheet of the tool. For each step of the production process, the amount of manufacturing costs actually incurred is estimated. In the calculation sheet, the manufacturing cost is divided into the following components:

- Direct material costs.
- Direct labour costs;
 - Green (metal injection moulding).
 - Brown (debinding).
 - White (sintering).
 - Post-processing and other.
- Manufacturing overhead costs;
 - Green (metal injection moulding).
 - Brown (debinding).
 - White (sintering).
 - External processing.
 - External quality control.
 - Other.

The direct material costs actually incurred per product are difficult to monitor. Currently, the total amount of materials used is computed once per month. Ideally, for each product, the amount of materials used should be monitored by the operators and communicated with the production manager by using the production orders or alike. This could require some additional workload for the operators and manager. The production manager of Company X does not think it is worth the time required for implementing this way of working yet. However, by monitoring the direct materials actually used for each product this way, the accuracy of the performance evaluation tool would increase and the managers would be able to perform cost variance analyses for the direct material costs, increasing the accuracy of the manufacturing cost variance. In the new tool, I added a sheet for computing the total costs of the materials used in a specific week or month. The data from this sheet are used based on the input from the drop-down list, which was mentioned in Section 6.2.1. In this sheet, the amount of materials used for manufacturing during a specific period is calculated by applying Formula 6.4 (Hilton, 2011).

$$\text{Materials Used} = \text{Beginning Inventory} + \text{Purchases} - \text{Ending Inventory}. \quad 6.4$$

Appendix J shows the format of the tables from the sheet. The amount of materials used is multiplied by the unit price of the materials to compute the total direct material costs actually incurred. When a new evaluation is performed, the user should copy the ending inventory to the beginning inventory, enter the new ending inventory and add the purchasing data. This way, an accurate estimation can be made for the total amount of materials used.

The amount of direct labour costs actually incurred is estimated with the use of the personnel data. These data include the number of hours spent on a specific activity of the production process for a specific product. Furthermore, operator wages are inputs of the tool. This way, the amount of labour costs actually incurred at each step of the production process by each product can easily be computed by multiplying the number of labour hours spent on the product by the hourly wage. This is done for each step of the production process to ensure a more detailed overview of the amount of costs actually incurred.

The amount of manufacturing overhead costs actually incurred is mainly based on the number of machine hours and runs used. In the current performance evaluation tool, the number of machine hours spent on a specific product is not monitored. Instead, the number of machine hours is equal to the number of labour hours, which is inaccurate, since much time is spent on other activities as well, such as machine setups and maintenance. It requires time-consuming changes in the current way of working for the manager and the operators to accurately monitor the actual number of machine hours spent on a specific product. First of all, the machine hours should be tracked by the operators. Secondly, these data should be uploaded to the server, such that the manager can insert the data into the performance evaluation tool. After a discussion with the production manager, I concluded that, for the short term, the managers of Company X do not think it is beneficial enough to spend much time on the implementation of the required changes in the current way of working yet. However, they should keep mind that, by implementing these changes, a more accurate estimation can be made for the manufacturing costs actually incurred. Furthermore, by monitoring machine hours and labour hours separately, the manager can compute the average number of effective machine hours, which can be used as input value for the price calculation tool. This way, a more accurate estimation can be made for the annual capacity of machine hours available, as discussed in Section 6.1.2.2.

The operators are unable to track the number of sintering runs used per product accurately, since different product types are stacked together for each run. So, in the calculations, the actual number of sintering runs used for each product is estimated based on the standard number of products per sintering run, which is an input value of the tool, as mentioned in Section 6.2.1. The sintering machine run rate, which is an input value as well, is multiplied by the expected number of sintering runs used per product to estimate the manufacturing overhead costs actually incurred. The estimated total number of sintering runs used in a specific period of time is compared with the actual total number of sintering runs, which is monitored by the managers. The actual total number of sintering runs is an input value of the tool, as mentioned in Section 6.2.1.

For computing the manufacturing overhead costs actually incurred by the debinding, external processing, quality control and other processing activities, standard unit costs are used. These standard unit costs are obtained from the price calculation tool, as mentioned in Section 6.1.4. By multiplying the standard unit costs by the number of products produced at the specific step of the process, the amount of manufacturing overhead costs actually incurred per product is estimated.

6.2.2.2 Cost Variances

For each product, the BCWP and actual cost are computed in the calculation sheet, thereby enabling the cost variance to be computed as well. On the first page of the dashboard, the cost variance for each product is shown. An example of this is shown in Appendix K. Products that have been processed in the specific period appear in the cost variance table. This table divides products with a positive cost variance and products with a negative cost variance. This way, the managers can quickly see which products are

performing above budget and which below budget. As explained in Section 4.2.2, a cost variance around 0% is favourable, a negative cost variance is unfavourable. A positive cost variance could indicate the cost price and selling price were set too high. Because of this, a company could miss out on sales. However, Company X agrees upon a fixed order size before the manufacturing of the specific product starts, meaning the company does not necessarily miss out on sales if the selling price is set too high.

On the second page of the dashboard, a more detailed cost variance analysis is included, as shown in Appendix L. For each product, this includes the following components:

- General cost variance.
- Cost variance green.
- Cost variance brown and white.
- Cost variance post-processing and other.
- Production variance green.
- Cost variance labour.
- Cost variance manufacturing overhead.

Each cost variance is measured in terms of percentages, as discussed in Section 5.2.2. By computing the cost variance for each of the categories mentioned, the user can quickly observe at which activity of the production process the actual costs are higher than expected. This enables the managers to act quickly, if necessary, and cut costs if possible. For example, at Company X, a cost variance lower than 0% for manufacturing overhead costs most likely indicates more machine hours are used than expected. This encourages the managers to focus on improving machine efficiency or productivity, such that higher costs are averted. The average cost variance is not the most useful measure for cost variance analysis. If a high average cost variance is observed, the managers would still not know which products and which activities are incurring more costs than expected. It would take more time to find the bottleneck of the production process. An extensive analysis of multiple different cost variances enables quick and effective cost reduction and provides a more accurate view on actual performances.

Unfortunately, the cost variance for direct materials could not be computed. At Company X, the amount of materials actually used is not monitored for each product. Instead, the total amount of materials used is estimated monthly. This would mean that the actual cost of direct materials for each product cannot be computed, meaning the cost variance for direct material costs cannot be computed either. As alternative, I added the production variance of the metal injection moulding machines as performance indicator. This variance is calculated by applying Formula 6.5.

$$\text{Production Variance Green} = \frac{\text{Actual Production Rate} - \text{Standard Production Rate}}{\text{Actual Production Rate}}. \quad 6.5$$

A negative production variance indicates fewer products are produced per hour than expected. For example, if the standard production rate equals three hundred products per hour and the production rate observed equals two hundred products per hour, the production variance equals -50%, meaning the production rate should increase by 50% to be equal to the standard rate. A negative production variance could indicate the machines experienced technical difficulties or the operators were not as productive as they should be. It could also mean many products were rejected, indicating a larger amount of materials is needed to produce the target quantity. So, the production variance is an interesting measure for the performance of the metal injection moulding machines, but a negative production variance does not necessarily imply a negative direct material cost variance.

6.2.3 Other Key Performance Indicators

The cost variance is the main KPI of interest in the new tool. However, general financial results and other KPIs can be used to quickly assess the performance of the production process as well. On the dashboard, the following financial KPIs are shown:

- Net result.
- Turnover per employee.
- Turnover per labour hour per employee.
- Gross margin (%).
- Net margin (%).

Next to financial KPIs, the dashboard includes the following operational KPIs:

- Machine capacity utilisation;
 - Metal injection moulding capacity utilisation.
 - Sintering capacity utilisation.
- Metal injection moulding process performance;
 - Average metal injection moulding machine performance.
 - Direct material cost variance.
 - Direct labour cost variance.
 - Manufacturing overhead cost variance.
- Sintering process performance;
 - Average stacking time per run.
 - Standard sintering runs.

The operational KPIs are mostly focussed on machine performance and productivity.

6.2.3.1 Financial Key Performance Indicators

As discussed in Section 5.2.1, absorption costing is the most suitable financial reporting method to implement in the new performance evaluation tool. This costing method enables the company to compute and compare general financial results easily, such as the net result. Table 16 shows a simplified format of the income statement applying absorption costing. This format is used on the dashboard of the new tool to provide a quick overview of the general financial results realised. This application of absorption costing is useful for managerial accounting purposes, but should not be used for financial accounting purposes, since it does not incorporate quotations from third parties. A more detailed overview of the components of the format applied is provided on the dashboard as well. These components are shown on the left of Figure 14 in Appendix K.

Sales revenue
Cost of goods sold (-)
Underapplied overhead (-)
Gross result
Operating expenses (-)
Net result

Table 16: Simplified format for the income statement for absorption costing.

In Section 4.2.1.3, I explained how the cost of goods sold account is computed. This formula is shown in Table 34 in Appendix M as well. In Table 16, the underapplied overhead is incorporated in the simplified income statement. Underapplied overhead arises if more manufacturing overhead is incurred than budgeted (Hilton, 2011). If less manufacturing overhead is incurred than budgeted, the underapplied overhead is negative.

The production manager wanted the turnover per employee and turnover per labour hour per employee to be added to the dashboard. Furthermore, I added the gross margin and net margin, since the value of these KPIs can easily be compared with previous results. The values of the financial KPIs are assessed based on target values as well. For example, the target net margin is X%.

6.2.3.2 Machine Capacity Utilisation

The machine capacity utilisation is one of the most important KPIs on the performance evaluation dashboard, since the price calculation tool uses these KPI values for overhead allocation, as explained in Section 6.1.2.2. The capacity utilisations of the metal injection moulding machines and sintering machines are calculated by applying Formula 6.6. The total machine hours and runs available are calculated by applying Formulas 6.7 and 6.8.

$$\text{Machine Capacity Utilisation} = \frac{\# \text{ Machine Hours or Runs Used}}{\# \text{ Machine Hours or Runs Available}} \quad 6.6$$

$$\begin{aligned} \# \text{ MIM Machine Hours Available} &= \# \text{ Working Days} \times \\ \# \text{ Daily Effective Machine Hours} &\times \# \text{ MIM Machines.} \end{aligned} \quad 6.7$$

$$\# \text{ Sintering Runs Available} = \# \text{ Working Days} \times \# \text{ Sintering Machines.} \quad 6.8$$

The new price calculation tool requires the average of the recent machine capacity utilisations as input, since using the single most recent value observed would be too biased. In the performance evaluation tool, I added a sheet containing the computation of the average machine capacity utilisations. But what is the best way to compute this average?

A simple moving average (SMA) is commonly used for calculating the average of a set of values. The SMA at the end of period t is calculated by taking the arithmetic mean of the set of n values $\{V_{t-n+1}, V_{t-n+2}, \dots, V_t\}$ (Slack et al., 2013), as shown in Formula 6.9. The values are summed and divided by the number of values. If an SMA is applied, the values are considered to be of the same importance.

$$SMA_t = \frac{V_{t-n+1} + V_{t-n+2} + \dots + V_t}{n} \quad 6.9$$

An alternative for calculating the average value of a set of values is the exponentially weighted moving average (EWMA), also known as exponential smoothing (Slack et al., 2013). This type of average is often used by professional traders. An EWMA is more reactive to the most recent data changes than an SMA, since the EWMA assigns a higher weight to the most recent data. The n -period EWMA at the end of period t is calculated by applying Formula 6.10 (Slack et al., 2013).

$$EWMA_t = V_t \times \frac{\text{Smoothing}}{1+n} + EWMA_{t-1} \times \left(1 - \frac{\text{Smoothing}}{1+n}\right). \quad 6.10$$

The smoothing factor is often assumed to be equal to 2 (Hayes, 2020). A higher smoothing factor would increase the influence of the most recent values. The smoothing factor divided by $1+n$ is known as the weighting multiplier or smoothing constant, with n is equal to the number of periods. The weighted multiplier should not be higher than 0.20, according to Chopra & Meindl (2013).

Another alternative for calculating an average value is the weighted moving average (WMA). The WMA at the end of period t is calculated by applying Formula 6.11. A weight is assigned to each value of the set of n values. For example, if one wants to let the third value have the biggest influence on the average, the highest weight should be assigned to this value. Often, the most recent values are assigned the highest weight (Corporate Finance Institute, n.d.).

$$WMA_t = \frac{w_{t-n+1} \times V_{t-n+1} + w_{t-n+2} \times V_{t-n+2} + \dots + w_t \times V_t}{w_{t-n+1} + w_{t-n+2} + \dots + w_t} \quad 6.11$$

In the performance evaluation tool, I applied the EWMA for computing the average machine capacity utilisation. The EWMA responds faster to value changes and trends, meaning it would increase the recency of the computed average. The calculation of the EWMA requires two input values: the smoothing factor and the number of periods. I recommend using a smoothing factor of 2 and a period

of 20 ($n = 20$), such that the weighted multiplier is lower than 0.20 and a sufficient amount of recent values is incorporated.

The user of the tool is able to add the observed machine capacity utilisation and EWMA to a list containing all previous machine capacity utilisations and EWMA. I recommend the managers of Company X to compute the machine capacity utilisation and EWMA of the metal injection moulding machines and sintering machines weekly and add the values observed to the list every time. So, if a period of 20 ($n = 20$) is used, the computed EWMA is based on the machine capacity utilisations and EWMA of the previous 20 weeks. Adding the values to the list with previous values on a monthly or daily basis would make the EWMA too recent or too out-dated, resulting in a misleading and biased average value.

6.2.3.3 Process Key Performance Indicators

I added five KPIs related to the performance of the metal injection moulding process to the performance evaluation dashboard. One of these is the average machine performance. The value of this KPI is the average of the machine performance of all products. The machine performance is part of the overall equipment effectiveness (OEE) and is computed in the calculation sheet for each product by applying Formula 6.13. Next to machine performance, machine availability and machine quality are components of the OEE as well. These components are computed by applying Formulas 6.12 and 6.14 (Slack et al., 2013).

$$Availability = \frac{\# Machine Hours}{\# Labour Hours}. \quad 6.12$$

$$Performance = \frac{Actual Units Produced \times \frac{1}{Standard Units Produced Per Hour}}{\# Machine Hours}. \quad 6.13$$

$$Quality = \frac{\# Good Units Produced}{\# Total Units Produced}. \quad 6.14$$

$$OEE = Availability \times Performance \times Quality. \quad 6.15$$

The OEE is a standard for measuring the productivity of machines and processes. It is computed by applying Formula 6.15 (Slack et al., 2013). An OEE of 100% implies equipment, such as machines, is used effectively, meaning it does not suffer from time losses, speed losses and quality losses. Since it is not possible to measure the number of machine hours actually used and the actual product failure rate at the metal injection moulding machines, the machine availability and machine quality cannot be computed. This means that the OEE cannot be computed either. The OEE is one of the most useful operational performance indicators, so the managers should definitely consider implementing this KPI.

As explained earlier, the direct material costs cannot be computed for each product. Instead, the total amount of direct material costs incurred is computed. Additionally, in the calculation sheet of the tool, the total amount of direct material costs expected to be incurred is computed. With this information, a cost variance can be computed for the total direct material costs. For this, Formula 5.2 should be applied. Furthermore, I added the cost variances of the direct labour costs and manufacturing overhead costs incurred by metal injection moulding. These cost variances provide better insight into the reason why more costs are incurred than expected. For example, a negative cost variance of direct labour costs would probably indicate more labour hours are spent than expected, possibly indicating the operators were not as productive as they should be.

For assessing the performance of the sintering process, two KPIs are used. The production manager wants a KPI monitoring the number of hours spent on loading and unloading the stacks, known as stacking. Usually, a total of 3 to 4 hours is spent on stacking. The total number of hours spent on stacking is retrieved from the personnel data and divided by the number of sintering runs actually used in the specific period. As mentioned in Section 6.2.1, the actual number of sintering runs used is an input value

of the tool. In the calculation sheet, the standard number of sintering runs needed is computed for each product. This number is calculated by dividing the total number of products sintered by the standard number of products per run. The sum of the standard sintering runs for each product is added as KPI to the dashboard, such that the managers can compare the actual number of sintering runs used with the standard number.

A useful KPI for the dashboard would be the daily effective number of metal injection moulding machine hours. This KPI is also required for computing the machine availability, which is a component of the OEE. Unfortunately, this KPI cannot be monitored yet. In the calculation sheet, the number of machine hours is assumed to be equal to the number of labour hours, meaning the daily effective number of machine hours is equal to the daily effective number of labour hours, which is assumed to be 7 hours, as explained in Section 6.1.2.2. To estimate the average annual capacity of metal injection moulding machine hours more accurately, the effective machine hours should be used. Currently, I assume that the daily effective number of machine hours equals 7 hours, which is acceptable if this number is used in the performance evaluation tool as well. If the machine hours are counted and monitored in the new tool, the average number of daily effective machine hours can be computed and used as input value of the price calculation tool. This average can be computed as exponentially weighted moving average (EWMA), similar to the average machine capacity utilisations. By using the effective number of machine hours, a more recent and accurate estimation can be made for the annual capacity of machine hours.

Another useful KPI to monitor is the actual product failure rate at a specific activity of the production process. This KPI is also a component of the OEE. The inventory data include the number of products rejected and the activity of the process at which these products were rejected. However, this does not say anything about the actual product failure rate at that specific activity of the process. Products of a specific product type can be rejected at a certain activity, but no products have to be produced at that activity necessarily. For example, if products were already sintered in the previous period, but rejected in the current period because of a quality assessment, it would imply a high product failure rate is observed, which is actually not the case. For this reason, I excluded the actual product failure rates from the dashboard.

6.2.4 Comparing Results with Previous Results

To compare the most important results with previous results, I added a sheet containing previous values on six KPIs. This sheet is called 'KPI History'. The format of this sheet is shown in Appendix N. Together with the production manager, I selected the following KPIs for this sheet:

- Total turnover.
- Sales revenue.
- Inventory change in value.
- Gross margin.
- Net margin.
- Average cost variance.

The total turnover is the sum of the sales revenue and inventory change in value. The inventory change in value is the sum of the work-in-process inventory change in value and finished goods inventory change in value. Additionally, the gross margin and net margin are added to assess profitability. These five performance indicators quickly show information about the overall financial performance of the company in a specific period and can easily be compared with previous results.

The cost variance is the most useful KPI for managerial accounting at Company X. It assesses the actual performance of the production process by comparing actual results with standard results. A cost variance close to 0% is favourable, indicating the price calculations are accurate and the consequences of

unexpected costs are limited. For comparing results between different periods, I added the average cost variance to the sheet.

The user is able to add the actual performance on the six KPIs to the list of previous results. This can be done on a weekly and monthly basis. As explained in Section 6.2.1, if the user selects '1 Month' as input value from the drop-down list, the results are copied to the list with the results from all previous months. If '1 Week' is selected from the drop-down list, the results are copied to the list with the results from all previous weeks. This sheet enables the managers to quickly compare the most important results between different periods.

6.3 Implementation

The price calculation tool should be used when a new order arrives. The computed output values should be copied to the performance evaluation tool, such that the actual results can be compared with the expected results. This enables the managers to perform cost variance analyses and to assess the performance of the production process based on standard results. In order to be able to perform cost variance analyses for products currently in the production process, the price calculation of these products should be used to add the standard costs and standard results to the performance evaluation tool. Currently, I added the standard values of a few products to the performance evaluation tool. The managers of Company X could use the old price calculations to add the standard values of all products. However, by performing a new price calculation by using the new tool, a more accurate estimation of the manufacturing cost price can be made and standard values can be copied to the performance evaluation tool more easily.

Usually, the production manager performs an evaluation once per week by using the performance evaluation tool. Furthermore, the general financial results are generated and reported once per month by using another tool. The new performance evaluation tool can compute results for any period. The user should be aware that the beginning and ending date of the two input files, the inventory data and the personnel data, should match. If this is not the case, a message is shown indicating the dates do not match. The 'KPI History' sheet contains results on six KPIs from previous months and weeks. I recommend the managers of Company X to add the observed results of each week and each month to the sheet, such that observed results can be compared with previous results. The 'KPI Output' sheet, used for computing the average capacity utilisation of metal injection moulding machines and sintering machines, requires the user to add the values observed to a list containing previous results. Ideally, new values should be added to the list once per week, such that the exponentially weighted moving average does not incorporate too recent or too out-dated data.

Chapter 7: Conclusions, Discussion and Recommendations

In this chapter, I summarise the results and answer the main research question. In addition, I discuss the results of my research and state recommendations for implementation of the new tools focussed on continuous improvement of the tools and cost variance reduction. Furthermore, I propose possible directions for further research on the subjects treated in this report.

7.1 Conclusions

A problem stated by the managers of Company X has challenged me to come up with an appropriate and effective solution. The accounting tools currently used do not provide accurate information and exclude essential indicators for assessing the performance of the production process, leading to ill-informed decisions by the managers. The managers desired new accounting tools that provide more accurate information about the costs incurred by manufacturing activities quickly, such that the difference between the actual and expected manufacturing cost, known as the manufacturing cost variance, can be more easily reduced. The process of identifying, managing and monitoring costs is known as cost accounting. This type of accounting is used for managerial accounting purposes, meaning the results obtained are intended to facilitate the decision-making process of the managers to ensure well-informed decisions are made. The accounting tools should include accurate calculations to maximise the quality of the information obtained. Before focussing on the reduction of variances, the accuracy of the results computed should be increased. Therefore, the main research question was formulated as follows:

Which cost accounting methods should be applied to reduce the manufacturing cost variance at Company X?

At Company X, cost ascertainment, the exploration and identification of costs to be incurred, plays an essential role. Product prices are set and agreed upon before manufacturing of the product starts, meaning the cost price should be estimated accurately. This requires accurate cost ascertainment. For this purpose, I developed a new tool for price calculations and focussed on ensuring the computations are as accurate as possible. In this tool, I implemented activity-based costing, a product costing method for allocating overhead costs to products. Activity-based costing is especially suitable if the cost-plus pricing strategy is applied. With this strategy, a company sets a selling price by adding a profit mark-up to the cost price, meaning an accurate estimation of the cost price is essential. In the price calculation tool currently used, non-manufacturing overhead costs were not allocated to products, possibly resulting in inaccurate cost prices and selling prices. Activity-based costing provides a well-motivated overhead allocation by dividing the company into activities. By doing this, the managers gain more insight into the costs actually incurred by these activities. To maximise the effectiveness of activity-based costing, a company should identify by which operations the overhead costs are incurred and what actually drives these operations. This way, cost drivers are identified more easily and can be connected to individual products. In the new tool, I selected metal injection moulding and sintering as the activities. These activities are the most costly parts of the production process. Overhead costs are indirect costs, meaning they are not directly related to an individual product. However, at Company X, these costs tend to increase when production increases, therefore I connected the production activities with the overhead costs in the overhead allocation. With this overhead allocation, the indirect costs can be connected to individual products.

I used the machine capacity utilisations of the metal injection moulding machines and sintering machines as cost drivers of the activities. This way, a product requiring relatively more machine hours or runs has to cover more overhead costs. The tool uses up-to-date information by using recent performances on machine capacity utilisation computed in the new performance evaluation tool. This results in better-motivated estimations of cost prices. Furthermore, this type of overhead allocation encourages the company to maximise its machine capacity utilisation. This can be done by increasing productivity, or by selling unnecessary machines. If the machine capacity utilisation is relatively high, the amount of

overhead costs to be allocated to new products is relatively low, resulting in relatively lower cost prices. Lower cost prices enable the managers to reduce selling prices to possibly increase sales, or to increase profit margins while offering the same selling prices.

The implementation of activity-based costing made the managers of Company X realise their products do not always cover the overhead costs fully with the current selling prices. Activity-based costing provides insight into the actual costs incurred by the company and emphasises the importance of accurate cost ascertainment. To stay in business, a manufacturing company must ensure all overhead costs are covered by its products. Therefore, a company should select the right product costing method very carefully. It should focus on maximising accuracy and should connect the costing method to its business strategies, such as pricing. A manufacturing company applying cost-plus pricing, thereby relying on accurate cost ascertainment, should definitely consider the implementation of activity-based costing to ensure all costs are covered by its products.

I also developed a new performance evaluation tool for Company X, enabling the managers to perform cost variance analyses. In general, the cost variance is a useful measure for assessing the performance of the production process of a company. The cost variance is especially useful if a company uses fixed price contracts, meaning a selling price is set before manufacturing (or construction) starts. This increases the importance of accurate cost control and budgeting, making detailed cost variance analysis very useful. The cost variance is the difference between the actual cost and the budgeted cost of work performed (BCWP), also known as the expected cost or standard cost. The BCWP is the costs expected to have been incurred during a specific period and is computed by using standard unit costs. These standard costs are computed for each product in the price calculation tool I developed for Company X. The tool includes a sheet containing data that should be copied to the new performance evaluation tool. This way, the actual cost can be compared with the BCWP, thereby enabling the managers of the company to compute cost variances.

In the new performance evaluation tool, I divided the actual manufacturing cost into its three components: direct material costs, direct labour costs and manufacturing overhead costs. The costs actually incurred are computed for each of these components, for each step of the production process and for each product. Because of this, a more detailed cost variance analysis can be performed, including cost variances of each type of manufacturing cost, each step of the production process and each product. This enables the managers to identify quickly which products are performing below expectations and why. The new tool also applies absorption costing for reporting general financial results, such as the net result and sales revenue. Absorption costing is easy to implement and enables the managers to compare the results realised with previous results.

The cost accounting methods applied in the tools I developed for Company X enable accurate and well-motivated calculations and provide useful information for effective cost management. The manufacturing cost variance is a very useful key performance indicator for assessing the performance of the production process of a manufacturing company. However, before focussing on reducing the manufacturing cost variance, managers should focus on increasing the accuracy of the calculations of their accounting tools. This way, the cost variance can be more accurately computed, providing more useful information. Accurate and detailed cost variance analysis would enable managers to identify bottlenecks more easily, thereby enabling them to act more quickly and avert higher costs more effectively. If the information obtained would assess the actual performance of the production process more accurately, it would lead to even better-informed decisions, easing the process of cost management and cost reduction.

7.2 Discussion

I developed two accounting tools that should be implemented at Company X to increase the accuracy of cost accounting and to enable the managers to perform cost variance analyses. The new price calculation tool includes a more detailed calculation of the manufacturing cost price, requiring more product-

specific input to ensure accuracy. Furthermore, non-manufacturing overhead costs are allocated to products by applying activity-based costing. The application of activity-based costing provides better insight into how a product is produced, how much time and how many resources are needed for the activities selected and how much is incurred by each activity (Kumar & Mahto, 2013). The overhead allocation method applied in the new tool uses average machine capacity utilisations as cost drivers, which are computed in the new performance evaluation tool. This method encourages the company to maximise the machine capacity utilisations, such that lower selling prices can be used. This can be done by increasing productivity of the machines or of the employees. Besides, the managers could consider selling some metal injection moulding machines, since the average machine capacity utilisation is often very low.

The overhead allocation method applied ensures all overhead costs are covered, even if a small number of products is produced at the facility. However, the arbitrariness of overhead allocation can never be eliminated. In the new tool, the overhead costs are separated into two cost pools based on percentages discussed with the production manager. In particular, 75% of the costs is allocated to the metal injection moulding activities and 25% is allocated to the sintering activities. Actually, for each product, this division is different, meaning these percentages are, in practice, not the same for each product. For example, Product A requires more metal injection moulding machine hours than Product B, but requires an equal number of sintering runs. Therefore, the costs incurred by metal injection moulding are higher for Product A than for Product B, meaning the actual percentages for the cost pools differ. I tried applying these actual percentages instead of the two general percentages (75% and 25%). However, this leads to more (or less) overhead to be covered than necessary, resulting in higher (or lower) and inaccurate selling prices. By using the same percentages for every product, the exact amount of overhead costs that has to be covered is actually covered.

The new performance evaluation tool enables the managers of Company X to perform cost variance analyses. The calculations of the tool are divided into several categories ensuring more accurate outcomes. However, several calculations require changes in the way of working of the employees, creating a higher workload for some. For example, the actual direct material costs cannot be computed for each product. Instead, the actual direct material costs are computed for all products together. The current way of working does not enable the managers to perform highly accurate computations of the actual manufacturing cost, therefore I discuss some recommendations for countering the inaccuracies in Section 7.3. Nonetheless, I managed to create a starting point for the managers to focus on continuous improvement of the accuracy of cost accounting at the company. The results computed in the new performance evaluation tool provide more detailed information about the actual performance of the production process, ensuring management to make better-informed decisions.

The tools include many calculations that are sensitive for validity issues. Therefore, I had a meeting with an employee from Company X who has experience with developing such tools. In this meeting, he helped me validating these calculations, ensuring the right numbers and formulas are applied. Many calculations are specific and can only be applied at Company X. However, some formulas discussed in this report can be applied to other companies, such as the cost variance and OEE. In addition, the concepts, methods and strategies treated in Chapters 2 and 4 are meant to provide a clear introduction to the problem statement and context of the problem and can be applied to other companies as well. The sources used are common in the field of accounting and finance and should therefore be considered as reliable sources.

Unfortunately, I was not able to analyse the benefits observed with the implementation of the new tools due to lack of time. However, the new tools provide a more thorough analysis of the performances observed, facilitating the decision-making process of the managers. By focussing on continuous improvement of the accuracy of the tools, the cost variance analysis becomes more useful for managing and monitoring the manufacturing cost.

7.3 Recommendations

In this section, I elaborate on recommendations for improving the new cost accounting tools. These recommendations are focussed on improving the accuracy of the tools and thereby enabling the managers to more accurately monitor the actual manufacturing cost, such that the cost variance analyses become more helpful. Furthermore, I discuss possible directions for further research on accurate cost accounting and cost variance analysis, creating a starting point for researchers.

7.3.1 Implementation

The new tools contain some room for improvement. The actual cost can be computed more accurately, such that the accuracy of the cost variance increases. The results generated would contain more accurate data, leading to better-informed decisions. Table 17 summarises the recommendations for implementation and continuous improvement of the new tools.

In the new performance evaluation tool, the actual cost of raw materials cannot be computed for each product. The employees, the operators in particular, do not count the amount of materials used for a specific product. To monitor the direct material costs actually incurred, the amount of materials used should be tracked. This means that the way of working of the operators should be adjusted. For example, the operators should track the amount of materials used for a specific product when materials are used. This can be done with the use of the production order or a separate log. At the end of the week, the production manager should count the amount of materials used for each product and add these data to a separate sheet of the performance evaluation tool. An example of this format is shown in Appendix O. Monitoring the amount of direct material costs actually incurred, enables the managers to perform cost variance analyses of the direct material costs for each product. A cost variance lower than 0% would indicate more materials are used than expected or the prices of the materials have increased.

The manufacturing overhead costs actually incurred, are covered by metal injection moulding machine hours. However, the machine hours are not tracked, meaning that the total amount of manufacturing overhead costs actually incurred cannot be accurately monitored for the metal injection moulding process. Instead, the number of machine hours consumed is assumed to be equal to the number of labour hours, which is inaccurate. A large proportion of the time spent at the metal injection moulding machines is spent on machine setups and maintenance, meaning one cannot assume the number of effective machine hours to be equal to the number of labour hours. The daily number of effective machine hours is used in the price calculation tool as well. If the effective number of machine hours is tracked, a more accurate estimation of the annual number of available machine hours could be made, which is used for the overhead allocation in the price calculation tool. The exponentially weighted moving average could be computed in the 'KPI Output' sheet of the performance evaluation tool and could be used as input for the price calculation tool.

As mentioned in Section 6.2.1, the actual number of sintering runs is an input value of the performance evaluation tool. So, this number should be tracked to assess the performance of the sintering machines. The standard number of sintering runs is computed in the tool and can then be compared with the actual number of sintering runs.

With the current and new performance evaluation tool, the managers are unable to compute the amount of manufacturing overhead costs actually incurred by the debinding processes. The employees count the inventory after metal injection moulding and after sintering, meaning inventory is not counted after the debinding processes. So, in the new performance evaluation tool, the amount of manufacturing overhead costs actually incurred by debinding is based on standard costs, meaning the number of products produced at debinding and sintering, which are taken together in the inventory data, is multiplied by the standard unit cost. To monitor the actual cost of debinding, Company X should track the number of debinding runs used and count the inventory at the debinding process. This would require a higher workload for the employees. However, it would enable the managers to perform more detailed cost variance analyses as well.

As explained in Section 6.2.3.3, the overall equipment effectiveness (OEE) is a useful performance indicator to track, but cannot be computed. It requires some changes to the way of working of the employees. To compute the OEE of the metal injection moulding machines, the number of products rejected at the machines should be tracked. This way, the actual product failure rate can be computed, which is one of the three components of the OEE. Another component cannot be computed either: the machine availability. The machine availability is concerned with the number of machine hours in proportion to the number of labour hours. The number of machine hours consumed is not tracked, as explained earlier in this section. Instead, the number of machine hours consumed is assumed to be equal to the number of labour hours, which is not correct. So, to track the OEE, the employees should track the number of machine hours consumed for a specific product. This also enables the managers to compute the manufacturing overhead cost variance of the metal injection moulding process. Furthermore, the operators should track the amount of materials used for each product, such that the actual product failure rate can be computed. Moreover, it would enable the managers to compute the direct material cost variance for each product.

The new tools require the managers to work carefully. For example, in the inventory data and personnel data, different names are used for the same product, requiring the calculation sheet to have separate columns for referring to the right product in the right data file. Careless working causes misconceptions and should therefore be prevented.

In general, it is important to update certain input values frequently, such as machine hour rates, hourly wages and material prices. Besides, to increase accuracy of the overhead allocation method, the managers should track the machine capacity utilisations of the machines and, if possible, the effective machine hours on a weekly basis. This way, the computations in the price calculation tool incorporate recent data and thereby increase the accuracy of the overhead allocation. Overhead allocation remains arbitrary, but by incorporating recent and relevant data, accuracy increases.

What?	Why?
Track the amount of materials used for each product.	To compute the actual cost of direct materials for each product, enabling the managers to perform a more accurate cost variance analysis.
Track the number of metal injection moulding machine hours consumed by each product.	To compute the actual cost of manufacturing overhead for each product more accurately, enabling the managers to perform a more accurate cost variance analysis. It also increases the accuracy of the overhead allocation if average effective number of machine hours is monitored and applied. Furthermore, it enables the computation of the overall equipment effectiveness (OEE).
Track the number of sintering runs performed.	To compute the total actual cost of manufacturing overhead more accurately.
Keep track of the inventory changes at the debinding processes.	To get more control over the work-in-process inventory, increasing the detail of the cost variance analysis.
Track the number of products rejected during each specific part of the production process, instead of only the total number of products rejected.	To compute the OEE and to perform a more accurate cost variance analysis.
Use the same product names in all accounting and administration files.	To prevent misconceptions.
Update the KPI Output sheet frequently (once per week).	To increase recency and accuracy of overhead allocation.

Table 17: Summary of recommendations for implementation and continuous improvement of the new tools.

7.3.2 Further Research

During my research, I did not have enough time to study the costs and benefits of implementing the changes mentioned in Section 7.3.1 profoundly. Company X could focus on executing cost-benefit analyses, such that a clearer image is created about the possible benefits of implementing the interventions proposed. With the new cost accounting tools, a larger amount of useful information can be generated than the tools currently used. By implementing the interventions proposed, the managers can generate even more useful information to facilitate the decision-making processes. However, the managers should consider whether the benefits are worth the costs incurred by and required time associated with the implementation of these interventions.

An interesting research topic is the possible impact of the implementation of activity-based costing on the competitiveness of the company. By applying cost-plus pricing in combination with activity-based costing, the importance of cost reduction increases, resulting in competitive advantages if costs are successfully reduced. One could study whether the new cost accounting tools helped Company X reduce costs and thereby increase competitiveness in the long term. Furthermore, the effectiveness of possible strategic changes within the marketing and selling operations on competitiveness could be an interesting topic for further research.

The tracking and monitoring of operational performance indicators could improve the quality of the performance evaluation tool. The OEE is a useful performance indicator to implement and enables the company to perform even more detailed cost variance analyses. The implementation of such performance indicators and its contribution to cost variance analyses are interesting topics.

The use of an exponentially weighted moving average (EWMA) for computing the average machine capacity utilisation ensures recent data is incorporated into the overhead allocation, as discussed in Section 6.2.3.2. This application of exponential smoothing ignores observable trends and seasonality. The machine capacity utilisations observed should be analysed for trends or seasonality, which could be incorporated into the EWMA by applying trend-corrected exponential smoothing, Holt's model, or trend- and seasonality-corrected exponential smoothing, Winter's model (Chopra & Meindl, 2013). The machine capacity utilisations are not monitored nor analysed yet, meaning I was not able to quantify possible periodicity and seasonality. By incorporating trends and seasonalities, a more accurate EWMA can be computed, resulting in a more accurate overhead allocation.

Another interesting research topic to consider is the forecast error for assessing the accuracy of the new price calculation tool. Forecast errors can be measured by comparing the total manufacturing costs actually incurred with the total manufacturing costs expected to be incurred. An example of a measure is the mean squared error (Chopra & Meindl, 2013). However, the forecast error can only be computed when the specific order is finished and if the total actual cost is tracked in the performance evaluation tool. Measuring forecast errors requires much time and effort, but it would be an interesting assessment of the accuracy of the price calculation tool.

With these recommendations, I would like to conclude my research.

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Appendices

Appendix A: Stakeholder Analysis: an Ethical Point of View

An important subject of ethics in research is people. It is important to know who you are dealing with and what their relationship is with your project. These people are called stakeholders, defined as a group of people who can affect or is affected by the achievement of the organisation's objectives (Freeman, Hitt, & Harrison, 2001). The people related to this project are mainly the people from the management team of Company X. The team consists of a managing director and a production manager. Furthermore, the inventory manager is involved with the project. This manager monitors inventory changes at the production facility and creates input for the performance evaluation tool. Also, the operators, might be affected by the results of this project. It depends on whether the managing director and production manager decide to change the way of working of these operators in order to increase accuracy of the cost accounting process.

In Figure 7, a visualisation of a stakeholder analysis is shown. It distinguishes the stakeholders based on their influence on and interest in the project. This method is frequently being used in practice.

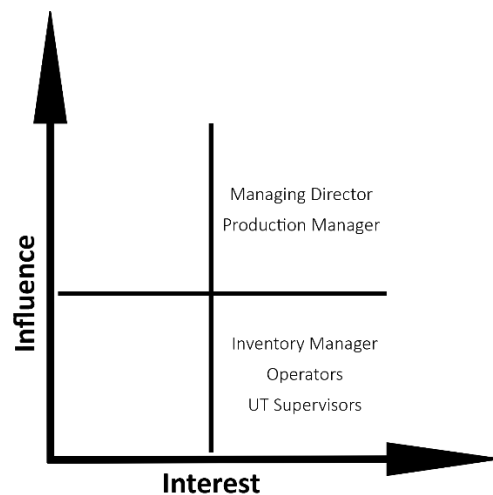


Figure 7: Stakeholder analysis.

The managing director is the problem owner. He is responsible for all key decisions being taken at the company. He will decide whether the solution to the problem will be implemented and how. Besides, he usually makes the price calculation if a new order arrives. So, when developing a new price calculation tool, the needs of the managing director have to be defined and taken into account. Certain decisions have to be discussed with the managing director, especially if there is a large possible influence on the current process.

The production manager is the main user of the performance evaluation tool, so he has a large influence on the design of the new tool. It is really important to stay in line with his needs. Furthermore, he is a useful source for primary data and for the problem identification process. Most interviews are conducted with this person, because he can give the best explanation about the current way of working and the occurring problems. Besides, he is a supervisor of this project and has the most time available.

The inventory manager has high interest in this project as well. He generates data for the performance evaluation tool, since he knows where the products are exactly and monitors changes of the inventory in the inventory management system. These changes are used in the evaluation tool to compute how many products are produced and how much revenue is created at the various steps of the production process. He should be informed whether the implementation of a new tool influences his way of working.

The operators are also important employees at the company. They operate the machines and count and check all products in the process. Especially the counting of the products is an important aspect of the process, since it is input for the inventory changes, which is managed by the inventory manager.

The supervisors from the University of Twente are also stakeholders with high interest in the project. They support and assess the research, so it is important to keep communicating with them. Their advice and trust are essential, so staying honest and keeping up with my responsibilities is of big importance.

Appendix B: Problem Cluster

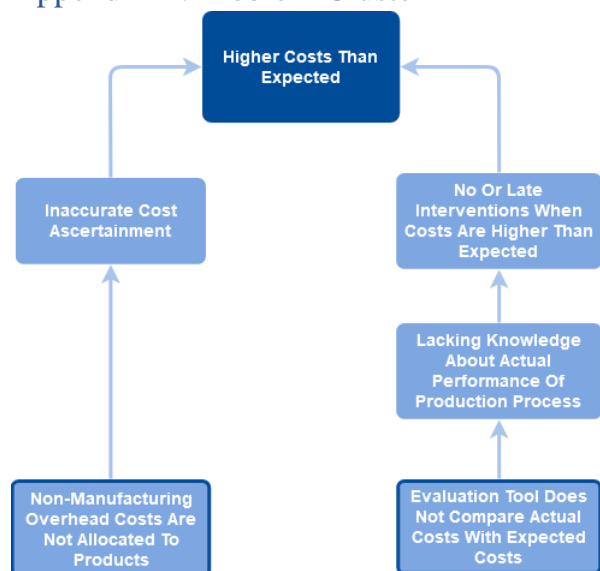


Figure 8: Problem cluster showing relevant problems observed at Company X and their causes.

Appendix C: Managerial Problem-Solving Methodology

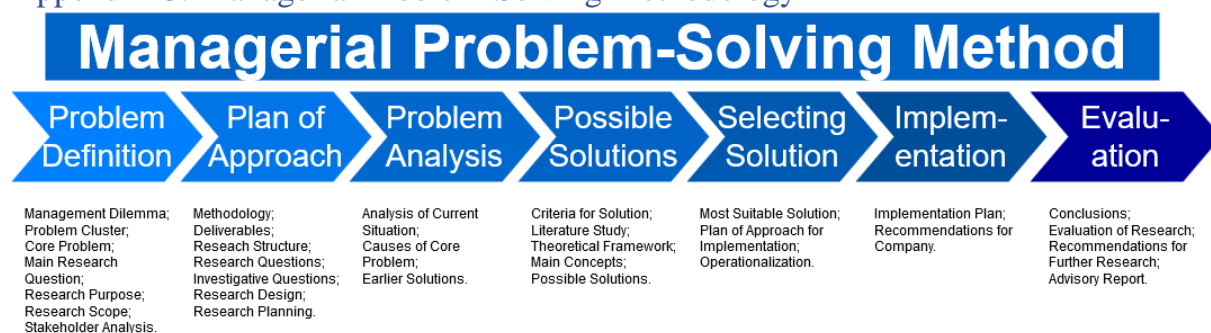


Figure 9: The seven stages of the Managerial Problem-Solving Methodology (Heerkens & Van Winden, 2017).

Appendix D: Research Designs

[this information is removed due to confidentiality]

Figure 10: Summary of research designs applied for a selection of (sub-)research questions.

Appendix E: Inputs of Price Calculation Tool of Company X

[this information is removed due to confidentiality]

Figure 11: Inputs of price calculation tool currently used.

Appendix F: Performance Evaluation Dashboard Currently Used at Company X

[this information is removed due to confidentiality]

Figure 12: Dashboard of performance evaluation tool currently used at Company X.

Appendix G: Numerical Examples of Income Statements When Applying Different Reporting Methods

Input				
		Month 1		Month 2
Units sold		10,000		10,000
Sales price	€	60.00	€	60.00
Units produced		10,000		20,000
Labour hours		1,000		1,000
Direct material price	€	15.00	€	15.00
Direct labour price	€	20.00	€	20.00
Variable MOH	€	5.00	€	5.00
Fixed MOH	€	50,000.00	€	50,000.00
Non-manufacturing overhead	€	125,000.00	€	125,000.00
Absorption costing product cost	€	45.00	€	42.50
Variable costing product cost	€	40.00	€	40.00

Table 18: Inputs for example income statements.

Absorption Costing				
		Month 1		Month 2
Sales revenue	€	600,000.00	€	600,000.00
Cost of goods sold (-)	€	450,000.00	€	425,000.00
Gross margin	€	150,000.00	€	175,000.00
Non-manufacturing OH (-)	€	125,000.00	€	125,000.00
Net income	€	25,000.00	€	50,000.00

Table 19: Numerical example of income statement when absorption costing is applied.

Variable Costing				
		Month 1		Month 2
Sales revenue	€	600,000.00	€	600,000.00
Variable product costs (-)	€	400,000.00	€	400,000.00
Variable margin	€	200,000.00	€	200,000.00
Variable non-manufacturing overhead (-)	€	25,000.00	€	25,000.00
Contribution margin	€	175,000.00	€	175,000.00
Fixed MOH (-)	€	50,000.00	€	50,000.00
Fixed non-manufacturing OH (-)	€	100,000.00	€	100,000.00
Net income	€	25,000.00	€	25,000.00

Table 20: Numerical example of income statement when variable costing is applied.

Appendix H: Systematic Literature Review

The systematic literature review methodology is used to tackle the following knowledge problem:

It is unsure which costing method should be applied to Company X.

This problem is tackled with the use of the following research question:

Which costing methods are most suitable for manufacturing companies like Company X and why?

The answer to this question is provided in Section 5.1.2. In the following paragraphs, the methodology used for executing the systematic literature review is explained.

Inclusion and Exclusion Criteria

Inclusion and exclusion criteria are used to set boundaries for selecting articles (University of Melbourne, n.d.). Articles that include an aspect from the inclusion criteria, are most likely being selected for the systematic literature review. Articles that include an aspect from the exclusion criteria, are not selected. The inclusion and exclusion criteria that are used for this systematic literature review are shown in Table 21.

Criteria for selection of articles	
<i>Inclusion</i>	<i>Exclusion</i>
The population used in the article: manufacturing company or companies	The article does not explain advantages of the treated costing method
The article compares multiple costing methodologies	The article is not in English nor in Dutch
The evidence is reliable and applicable to the situation of Company X	The costing methodology that is discussed is not applicable to manufacturing companies
The article includes an analysis of effectiveness of the implementation of a costing methodology	

Table 21: Inclusion and exclusion criteria for systematic literature review.

Databases

Table 22 shows the four databases that are used for this systematic literature review.

Database	URL	Comment
Business Source Elite (EBSCO)	https://web-a-ebSCOhost-com.ezproxy2.utwente.nl/ehost/search/advanced?vid=0&sid=ac77d28f-55ec-432c-a7bb-e60406fe0aa6%40sessionmgr4008	Gives the most relevant results; easy-to-use advanced search option
Google Scholar	https://scholar.google.com/	Gives the most results; many sources are inaccessible
JSTOR	https://www.jstor.org/	Gives the fewest results
UT Library	https://ut.on.worldcat.org/search	Mostly books; some are not downloadable

Table 22: Databases used for systematic literature review.

Search Terms and Strategy

The CIMO framework is applied to clearly define the search strategy (University of Maryland, n.d.). It includes important constructs, terms and synonyms to provide better results. A CIMO framework separates the constructs based on four aspects: context, intervention, mechanisms and outcomes. Table 23 elaborates on this framework.

CIMO	Constructs	Related terms	Broader terms	Narrower terms
<i>Context</i>	Activity-based Standard Target			
	Costing	“Product valuation”	“Cost accounting”	Pricing
	“Manufacturing company” “Manufacturing company”	“Production company” “Production company”		
<i>Intervention</i>	Method	Model Technique Strategy	Theory Approach System	
<i>Mechanism</i>			Approach	Implementation
<i>Outcomes</i>		Accura* Reliab*		Effectiv*

Table 23: Search terms and strategy for systematic literature review.

Protocol

Table 24 shows all search strings that are used in this systematic literature review. In addition, the databases used for a specific search string are mentioned.

Search String	Database*	Extra Criteria	# articles found	# articles selected**
“costing methods” AND “manufacturing company”	EBSCO	English	17	2
	JSTOR		16	0
	Google Scholar		644	3
	UT Library		6	0
Implementation AND “cost accounting” AND manufacturing	Google Scholar		38600	2
	EBSCO		346	0 (not relevant/ too much)
“activity-based costing” AND implementation AND (manufacturing OR production)	EBSCO	English	90	2
Accura* AND (costing OR “cost accounting”) AND method*	EBSCO	English	12	0 (not relevant)
(“cost accounting” OR costing) AND (method* OR strategy OR technique) AND (accura* OR effective* OR reliab*)	EBSCO	English	39	0 (not relevant)
(“cost accounting” OR costing) AND (manufacturing OR production) AND (accura* OR effective* OR reliab*)	EBSCO	English	22	0 (not relevant)
(“cost accounting” OR costing) AND (manufacturing OR production) AND (method* OR strategy* OR technique*)	EBSCO		79	0 (not relevant)
(“cost accounting” OR costing) AND (manufacturing OR production) AND target	EBSCO	English	40	0 (not relevant)
	UT Library	Downloadable	3481	0 (too much)
Total # selected articles				9

Table 24: Search protocol for systematic literature review.

*Four different databases are used, though Google Scholar and EBSCO gave the most relevant results. Later on, when using more specific search terms, Google Scholar gave too many results, so EBSCO was mostly used. The other databases were also used for each search term, though, they mostly gave too many results and are thus excluded from Table 24.

**The selection of articles is based on exclusion and inclusion criteria. Furthermore, titles, abstracts, introductions and conclusions are read.

Key Findings

Table 25 provides a clear summary of the key findings from the nine selected articles relating to the topic and concepts that are relevant for this systematic literature review. These articles are selected based on the inclusion and exclusion criteria from Table 21.

Article #	Title	Author	Year	Concepts	Key Findings
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1	Implementation of an activity-based costing system in a small manufacturing company	Baharara and Lee	1996	Implementation of ABC	ABC provides accurate product costs, estimated costs for special orders, new product development costs and data for continuous improvement. Especially when tracing time spent on activity by each product.
2	A new process-based cost estimation and pricing model considering the influences of indirect consumption relationships and quality factors	Tang, Wang and Ding	2012	Improvement of traditional ABC	ABC can result in estimation errors of around 5%, but by applying a process-based model based on process consumption and quality, errors of 2% can be achieved.
3	Activity-based costing: an emerging foundation for performance management	Turney	2008	Trends in ABC over the years and its applications	ABC applications, management of: profitability, performance, financial, sustainability and human capital.
4	Traditional versus activity-based product costing methods: a field study in a defense electronics manufacturing company	Meyers	2009	ABC vs. traditional costing in a manufacturing company	Traditional costing indeed leads to product cost distortions and under-costing. Traditional costing seems to be outdated.
5	Application of activity-based costing in a manufacturing company: a comparison with traditional costing	Tuncel, Akyol, Bayhan and Koker	2005	ABC vs. traditional costing in a manufacturing company	ABC is capable of monitoring hidden losses and profits of traditional costing. It gains insight into how a product is produced, how much time is needed for an activity and how much money is absorbed by each activity.
6	A comparative analysis and implementation of ABC and TCA methods in an automobile parts manufacturing company: a case study	Kumar and Mahto	2013	ABC vs. traditional costing in a manufacturing company	ABC provides better insight into true costs of parts, meaning the use of TCA can lead to inaccuracy and loss of profits.
7	Time-driven activity-based costing: an implementation in a manufacturing company	Öker and Adigüzel	2010	Time-driven ABC vs. standard ABC in a manufacturing company	TDABC eases the process of updating the costing system if activities change. Furthermore, it allocates overhead costs to departments

					instead to all individual activities. Also, capacity utilisation can be analysed.
8	Implementation of activity-based costing in manufacturing	Gunasekaran and Sarhadi	1998	Implementation issues of ABC in manufacturing	Successful implementation requires: top management commitment, education and training of employees on ABC, incentives to motivate the employees in implementing ABC.
9	A comparative analysis of perceived and actual benefits from implementation of activity-based costing in selected manufacturing units in India	Arora and Raju	2018	Actual benefits from implementation of ABC in manufacturing	No significant difference between perceived and actual benefits from implementing ABC: accurate cost control, cost reduction, increase competitiveness, increase profitability, etc.

Table 25: Key findings of systematic literature review.

Conceptual Matrix

Table 26 provides a framework, a conceptual matrix, of the main concepts that are relevant for answering the research questions. Four concepts are used, and their application in the nine selected articles is studied. This framework is used for generating a structured answer to the research question, which is elaborated in section 4.3. If an article treats a concept, an X is shown in the conceptual matrix. The article numbers relate to the articles from Table 25.

Article	Concept			
	Activity-based costing	Implementation	Manufacturing	Traditional costing
1	X	X	X	
2	X		X	
3	X			
4	X		X	X
5	X	X	X	X
6	X	X	X	X
7	X	X	X	
8	X	X	X	
9	X	X	X	

Table 26: Conceptual matrix for systematic literature review.

Appendix I: Standard Overhead Costs

Type of Overhead	Monthly Standard Costs	Manufacturing Activities		Other Activities	
	€		€ -		€
	€		€ -		€
	€		€		€
	€		€		€
	€		€ -		€
	€		€ -		€
	€		€ -		€
	€		€ -		€
	€		€ -		€
	€		€ -		€
Total	€ 50,000.00		€ 10,000.00		€ 40,000.00

[information is removed due to confidentiality]

Table 27: Standard overhead costs.

Appendix J: Format for Computing the Direct Materials Costs

[this information is removed due to confidentiality]

Figure 13: Format for computing the direct material costs in the new performance evaluation tool.

Appendix K: Dashboard of the Performance Evaluation Tool Developed [this information is removed due to confidentiality]

Figure 14: First page of new dashboard.

Appendix L: Second Page of the Dashboard of the Performance Evaluation Tool Developed [this information is removed due to confidentiality]

Figure 15: Second page of new dashboard.

Appendix M: Financial Formulas

Sales Revenue
Finished Goods Inventory Change (+)
Work-In-Process Inventory Change (+)
Total Turnover

Table 28: Total turnover.

Direct Material Costs Green
Total Direct Material Costs

Table 29: Total direct material costs.

Direct Labour Costs Green
Direct Labour Costs Brown + White (+)
Direct Labour Costs Post-Processing & Other (+)
Total Direct Labour Costs

Table 30: Total direct labour costs.

Manufacturing Overhead Green
Manufacturing Overhead Brown (+)
Manufacturing Overhead White (+)
Manufacturing Overhead External Processing (+)
Manufacturing Overhead Quality Check (+)
Manufacturing Overhead Other (+)
Total Manufacturing Overhead Costs

Table 31: Total manufacturing overhead costs.

Direct Material Costs
Direct Labour Costs (+)
Manufacturing Overhead Costs (+)
Total Manufacturing Costs

Table 32: Total manufacturing costs.

Labour Non-Manufacturing Overhead Costs
Other Non-Manufacturing Overhead Costs (+)
Total Non-Manufacturing Overhead Costs

Table 33: Total non-manufacturing overhead costs.

Direct Material Costs
Direct Labour Costs (+)
Manufacturing Overhead Costs (+)
Work-In-Process Inventory Change (-)
Cost of Goods Manufactured
Finished Goods Inventory Change (-)
Cost of Goods Sold

Table 34: Cost of goods manufactured and cost of goods sold.

Appendix N: KPI History Sheet of Performance Evaluation Tool Developed

[this information is removed due to confidentiality]

Figure 16: KPI History sheet of new performance evaluation tool.

Appendix O: Example Format for Computing Actual Direct Material Costs per Product

Product Name	Material A €3 per kg	Material B €2,50 per kg	Material C €4 per kg	Total Costs
Product 1	20 kg			€60.00
Product 2		2 kg		€5.00
Product 3	3 kg	4 kg		€19.00
Product 4			13 kg	€52.00

Table 35: Numerical example for computing actual direct material costs per product.

Appendix P: Example of Three Products Together Covering All Overhead Costs [this information is removed due to confidentiality]

Figure 17: Overhead allocation for example Product X.

MIM Machine Hours Needed	3,645
Sintering Runs Needed	222
Total Overhead Applied	€151,942.53 + €54,411.76 = €206,354.29

Table 36: Summary of results for example Product X.

[this information is removed due to confidentiality]

Figure 18: Overhead allocation for example Product Y.

MIM Machine Hours Needed	3,888
Sintering Runs Needed	133
Total Overhead Applied	€162,072.03 + €32,598.04 = €194,670.07

Table 37: Summary of results for example Product Y.

[this information is removed due to confidentiality]

Figure 19: Overhead allocation for example Product Z.

MIM Machine Hours Needed	1,463
Sintering Runs Needed	155
Total Overhead Applied	€60,985.44 + €37,990.20 = €98,975.64

Table 38: Summary of results for example Product Z.

MIM Machine Hours Needed	3,645 + 3,888 + 1,463 = 8,996
MIM Machine Hours Annual Capacity	8,996
Sintering Runs Needed	222 + 133 + 155 = 510
Sintering Runs Available	510
Total Overhead Covered	€206,354.29 + €194,670.07 + €98,975.64 = €500,000.00
Total Overhead To Be Covered	€500,000.00

Table 39: Summary of results for examples Product X, Product Y and Product Z.

Appendix Q: Assigning Percentages To Cost Pools Based On Cost Prices

Product	Metal Injection Moulding (% of Manufacturing Cost Price)	Debinding & Sintering (% of Manufacturing Cost Price)
1		
2		
3		
4		

5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
Average	75	25

Table 40: Costs incurred by metal injection moulding, debinding and sintering in proportion to the manufacturing cost price for twenty products.

[information is removed due to confidentiality]