DEVELOPING A TIME-DRIVEN ACTIVITY-BASED COSTING SYSTEM FOR ALLOCATING VARIABLE MANUFACTURING OVERHEAD COSTS TO PRODUCTS

Lappeenranta–Lahti University of Technology LUT

Industrial Engineering and Management Master's Thesis 2024

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ABSTRACT

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Keywords: overhead cost, indirect cost, product costing, variable costing, time-driven activity-based costing, TD-ABC, ERP

The goal of this research is to develop a time-driven activity-based costing (TD-ABC) system for allocating variable overheads in a manufacturing company. Current overhead allocation methods in the case company are insufficient, which is manifested as unreliable sales margins and incomparable financial statements and managerial reports. The research is focused on enhancing the accuracy of variable overhead cost allocation to products through a new product costing approach aligning with IFRS IAS 2 inventory standards.

A design science research (DSR) methodology was adopted to efficiently combine theoretical knowledge with industry expertise and procedures in product costing. A literature review is utilized to explore core management accounting principles and various approaches in product costing. The research also includes an empirical portion, which sheds light on practical implementation challenges, key constraints, financial metrics, and managerial insights of system development.

The key deliverable of this research is a constructed framework for TD-ABC system development in manufacturing companies. The framework addresses managerial, organizational, and technical dimensions, ensuring a comprehensive development process description to overcome limitations and meet strategic business objectives of the company. The system was successfully implemented in a pilot unit in accordance with the constructed framework. Plans for further development and improvement of the system were also produced. Overall, the TD-ABC system provides valuable insights to product costs and sales margins, which together facilitate better cost transparency and business decision-making. The research not only benefits the selected manufacturing company, but also offers useful practical findings for academic purposes and further research, with possibility of transforming costing approaches in a wide range of industries.

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Tämän tutkimuksen tavoite on kehittää aikaperusteinen toimintolaskentajärjestelmä (TD-ABC) valmistavan teollisuuden yritykselle. Laskentajärjestelmän tavoitteena on allokoida valmistuksen muuttuvia yleiskustannuksia tuotteille. Yrityksen nykyiset yleiskustannusten allokointimenetelmät vaikuttavat negatiivisesti tuotetason kustannusten ja myyntikatteiden luotettavuuteen sekä sisäisten ja ulkoisten raporttien vertailukelpoisuuteen. Tutkimus syventyy keinoihin parantaa yleiskustannusten allokointia tuotteille uuden IFRS IAS 2 -varastoihin yhteensopivan laskentajärjestelmän kautta.

Tutkimuksessa hyödynnetään suunnittelutieteellistä metodologiaa, joka yhdistää tehokkaasti teoreettista tietoa sekä alan asiantuntijuutta kohdeyrityksessä. Kirjallisuuskatsausta hyödynnetään johdon laskentatoimen peruskäsitteiden selvittämiseksi sekä erilaisiin kustannuslaskentamalleihin perehtymiseksi. Empiirinen osio valottaa uuden järjestelmän käyttöönoton rajoitteita ja keskeisiä haasteita teknisellä, organisationaalisella sekä johtamistasolla.

Työn keskeisenä tuotoksena on kehitys- ja käyttöönottoprosessista koottu viitekehys, joka huomioi mahdollisia rajoitteita edellä mainituilla osa-alueilla ja tuottaa kokonaisvaltaisen kuvauksen keinoista toteuttaa järjestelmän käyttöönotto onnistuneesti, samalla tyydyttäen yrityksen liiketaloudelliset tavoitteet. Kehitetty laskentajärjestelmä otettiin onnistuneesti käyttöön pilottiyhtiössä tuotettua viitekehystä noudattaen. Tutkimuksessa esitellään myös tavoitteita järjestelmän jatkokehitykselle. Kokonaisuudessaan, TD-ABC järjestelmä tuo esiin tärkeitä yksityiskohtia tuotekustannuksista ja kannattavuuksista, ja mahdollistaa tehokkaampaa päätöksentekoa kohdeyrityksessä. Tutkimus ei pelkästään hyödytä kohdeyritystä, vaan tarjoaa tärkeitä käytännön havaintoja akateemisiin käyttökohteisiin sekä jatkotutkimusta ja laajempaa hyödyntämistä varten.

PREFACE

I want to address my exceptional opportunity to not only conduct research related to the development of a new costing system, but also to deeply engage in the practical development process within the company. None of this would be possible without the support and encouragement of a great team of colleagues, with whom I have the pleasure of working with.

Due to the confidential nature of this research, I cannot directly name the people involved, but I want to especially thank my previous and current supervisors for seeing my potential and helping me advance to where I am now. I also want to give a huge thanks to my colleagues in the Finnish and Slovakian manufacturing units for your cooperation, insights, and patience.

An additional token of appreciation goes to my friends and family who have tirelessly listened to me talk on and on about a topic they have no association with but still show great interest regardless.

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1 Introduction

1.1 Background

Product costing aims to accurately and reliably account product costs according to the principle of causation. The information from product costing is used for various purposes, most importantly as a tool to guide decision-making in production and sales. (Suomala, Manninen & Lyly-Yrjänäinen 2011, p. 106) Product costing systems can be split into two groups: traditional costing systems and activity-based costing systems. The main difference between these systems is the way of allocating overhead costs. In short, any costs that are incurred as a part of manufacturing that aren't direct materials or direct labor are considered as manufacturing overhead costs. (Horngren, Datar & Rajan 2012, p. 59). According to Cooper and Kaplan (1988, p. 24) overhead costs are often significantly large in manufacturing companies, and wrongful allocation can severely distort product costs. However, activity-based costing in its various forms is considered as the most accurate and reliable way of allocating overhead costs while also retaining direct cost correctness. (Järvenpää, Länsiluoto, Partanen & Pellinen 2010, p. 128)

This thesis focuses on the implementation process of a time-driven activity-based costing (TD-ABC) system in a large manufacturing company. The case company operates in the construction manufacturing industry and produces concrete connections and composite structures for building applications. Currently, the case company is only accounting direct variable costs to product stock value and is suffering from lacking cost accuracy due to the current overhead allocation methods. The company has however emphasized the importance of improving the accuracy and reliability of internal cost reporting. The main topic of improvement is to gain accuracy to product costs, sales margins, and profitability figures. An additional goal is to increase comparability between managerial and financial report figures by allocating variable overhead costs directly to product stock value with a new product costing approach. A new TD-ABC costing system will be implemented to the company's ERP system to meet the goals of accurate product cost information and reconciliation of financial and managerial reporting. The new system will also aim to standardize and harmonize product costing procedures in the company's manufacturing units. The long-term aim is to create a costing system which is compliant with the International Financial Reporting Standards (IFRS) IAS 2 inventory, in which all manufacturing overhead costs, including variable and fixed overhead costs are included in the inventory value (IFRS 2023). By successfully adopting a new product costing system, the company can achieve reliable sales margins down to product level while facilitating a controlled and harmonized costing process in all units to guide operative and strategic decision-making.

1.2 Objectives and scope

The aim of this research is to develop an ERP-integrated TD-ABC system for a manufacturing company and to produce a comprehensive development framework for the process. A time-driven activity-based costing (TD-ABC) approach is used to allocate manufacturing variable overhead costs directly to the stock value of goods through production postings in the ERP system. Thus, the goal is to achieve full variable cost absorption through a TD-ABC approach. This thesis is focused on the requirements and tasks related to developing and implementing a new product costing system in the case company. The research questions are as follows:

1. What specific aspects of internal reporting of a manufacturing company can be improved by implementing a new product costing system which considers variable overhead costs on a product level?
2. Which critical factors in the development of product costing systems are essential to ensure accuracy and reliability of variable overhead cost allocations?
3. What are the key stages in the development of TD-ABC systems in manufacturing environments, and how do they contribute to the system’s practical applicability and subsequent effectiveness in decision-making?

The research questions assess the impacts of TD-ABC systems on internal processes, the critical factors in system development and implementation, as well as the system’s effectiveness as a decision-making tool. The first research question focuses on the benefits in internal reporting by utilizing a TD-ABC approach in product costing, thus creating a goal-oriented starting point for costing system development. The second question is focused on simplifying the complex nature of product costing system development processes in the case company. The third question considers the necessary actions to take to ensure allocation accuracy and costing system reliability. Together, the research questions provide a goal-oriented implementation framework, in which concrete tasks related to preparation, technical topics, stakeholder management and organizational change are examined.

The scope of this thesis is delimited to the development process of TD-ABC systems in manufacturing companies for overhead cost allocation to stock value. Research and findings related to conventional ABC systems are also utilized given their similarity with TD-ABC. The empirical research will focus solely on the chosen manufacturing company and its parent entity and manufacturing units. The new costing system is planned to be implemented in all manufacturing units during 2024. Practical findings and other data from the case company are delimited to years 2020 through 2024.

1.3 Methods and data

This thesis utilizes a Design Science Research (DSR) approach. DSR methodology aims to solve real-world problems through the construction of models, plans or frameworks (Kasanen, Lukka & Siitonen 1993, p. 245). By this definition, DSR can be seen as a very similar approach as constructive methodology. Figure 1 illustrates the key elements of DSR problem solving.

Figure 1: Key elements of constructive research (Kasanen et al. 1993, p. 246)

According to Lukka (2001) and vom Brocke, Hevner and Maedche (2020, p. 1), DSR provides an innovative construction to a problem through close collaboration between the researcher and practical representatives. The goal is to facilitate experiential learning, which is carefully linked to existing theoretical knowledge by reflecting empirical findings to literature. Ultimately, DSR is a paradigm which develops knowledge that can be used in designing solutions to problems. (Van Aken 2004, p. 25)

Neilimo and Näsi (1980) introduce an accounting research methodology typology in which research approaches are categorized into 4 groups based on their normative, descriptive, theoretical, and empirical characteristics (Figure 2). As a methodological research approach, DSR can be seen as an empirical and normative study. It's closely linked to the decision-oriented approach with similar procedures for using theoretical analysis as means to guide the development of frameworks, models, or other constructions. However, DSR has more emphasis on empirically testing the practicality of the resulting construction. The action-analytical approach is also akin to DSR as they both directly assess empirical findings through grounded research and case study methods. The main difference between these studies is that action-analytical research doesn't contain the same normative goals in problem-solving which are characteristic of design sciences. (Lukka 2001)

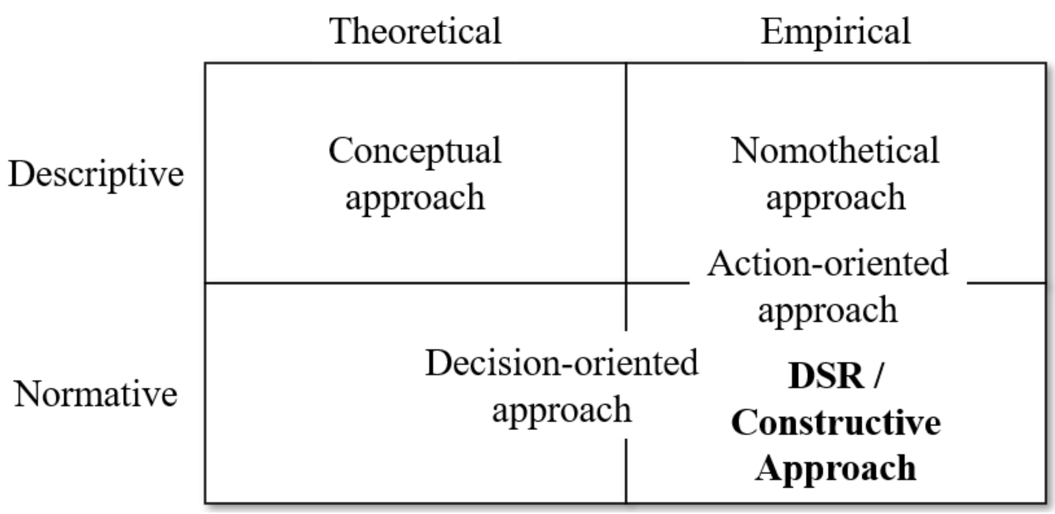

Figure 2: The location of DSR in the established accounting research typology (based on Kasanen et al. 1993, p. 257; Lukka 2001; Van Aken 2004, p. 25)

This research consists of a theoretical and empirical section. The theoretical research includes a literature review, in which textbooks and peer-reviewed scientific articles are used to gain insight to management accounting core concepts, product costing methods, activity-based costing systems and change management. LUT Scientific Library's search service Primo is utilized to find textbooks. Google Scholar search service along with Elsevier Scopus and IEEE XPlore databases are utilized to find scientific articles related to the topic. Keywords for research are "management accounting", "cost management", "indirect cost", "overhead cost", "product costing", "activity-based costing", "ABC", "time-driven activity-based costing", "TD-ABC", "ERP", "change management", "variable costing", "absorption costing" and various combinations of these keywords. The empirical research relies on practical findings and data collected from the implementation process of the TD-ABC system in the chosen manufacturing company. The practical findings and empirical data will be used to form a detailed description of the goals and issues related to implementation of the new product costing system and will act as the basis for developing the TD-ABC system.

1.4 Structure of the thesis

This thesis consists of 8 chapters. The first chapter is an introduction, in which the background, objectives, scope and research design are showcased. Chapter 2 focuses on introducing the basic concepts and limitations of management accounting as well as basic terminology related to the field of research. Chapter 3 describes different product costing methods, with a special emphasis on activity-based costing approaches. Chapter 4 entails an overview of the case company and discusses the key challenges and goals of costing in the company. These challenges and goals are used determine the correct product costing system approach, and to create goal-oriented boundaries for the system. Chapter 5 discusses the implementation process of the new product costing system in the case company. In this chapter, the basic structure of the TD-ABC product costing approach is created, and milestones of the implementation process are showcased in the form of a comprehensive development framework. Chapter 6 examines the functionality of the system and assesses the strengths and weaknesses as well as future development of the system. The conclusions of the research are presented in chapter 7. Chapter 8 contains the summary of this thesis.

2 Concepts of management accounting

2.1 Management accounting and financial accounting

Exploring the core concepts of management accounting as well as various approaches to product costing and inventory valuation forms the scaffolding upon which the empirical portion is constructed. Understanding the presented management accounting principles and methods is essential for two primary reasons:

First, the theoretical frameworks and principles provide a lens through which the empirical data from the case company can be examined critically. This applies especially to the classification of costs and their relation to manufacturing activities. Second, the methodologies and concepts discussed in this chapter are tools that enable us to dissect various costing approaches to fully assess their benefits and drawbacks, and to further reconstruct them into testable and applicable models in real-world scenarios. The extensive theoretical portion will ensure that the development of a TD-ABC system is not only grounded in management accounting theory, but also tailored to address the specific needs of the case company.

According to Jyrkkiö and Riistama (1996, p. 13) accounting is systematic activity focused on collecting and registering quantitative figures from a company’s operations and compiling reports and calculations based on these figures to benefit company management, financers, along with other internal and external stakeholders. Accounting can be divided into two separate areas of focus: financial accounting and management accounting (Neilimo & Uusi-Rauva 2012, pp. 12-15). This research will focus mainly on management accounting topics.

The task of financial accounting is to report value and quantity figures describing the company's finances for accounting purposes. The purpose is to communicate the company's financial events to stakeholders and external parties, such as banks and investors (Miller-Nobles et al. 2019, p. 28). Management accounting tasks on the other hand, as identified by Pellinen (2006, pp. 12–15), are focused on producing information to support decision-making for internal stakeholders within the company and facilitating operational efficiency and effectiveness through aiding in decision-making. The key differences of financial and management accounting are presented in table 1.

Table 1: Key differences between management accounting and financial accounting (based on Neilimo & Uusi-Rauva 2012, pp. 12-15; Masztalerz 2013, p. 47)

Criteria	**Financial Accounting**	**Management Accounting**
1. Quality of information	• According to GAAP and tax legislation	• Company-specific regulations
2. Measurement object	• Value of assets and liabilities • Company as a whole	• Company, business unit, process, lot, product
3. Orientation of information	• Historical data • Realized data	• Historical data • Forecasting and future data
4. Primary users	• External parties, banks, investors, creditors	• Internal parties, managers, shareholders, employees
5. Reporting timeframe and style	• Yearly, quarterly • Financial statements	• Hourly, daily, weekly, monthly • Financial and non-financial

Both areas of accounting are based on the same principles of cost accounting. Cost accounting provides information for both management accounting and financial accounting, aiming to measure and analyze both monetary figures and quantitative information. The core purpose of cost management is adding value for the customer, as well as maximizing profitability and profits (Miller-Nobles et al. 2019, p. 30).

2.2 Cost classifications in the manufacturing industry

2.2.1 Direct and indirect costs

Cost can be defined as a resource that is sacrificed or used to achieve a specific goal. Costs are typically defined as a monetary sum paid for goods or services. Actual costs are the costs incurred in the operation. Budgeted costs, on the other hand, are anticipated or pre-estimated costs. When comparing the realization of actual costs to budgeted costs, it is referred to as retrospective accounting (Neilimo & Uusi-Rauva 2012, p. 230). The success of budgeted costs is a crucial factor for the predictability and control of business operations, as precise budgeting enables the efficient use of resources (Miller-Nobles et al. 2019, p. 352). Cost objects, to which both budgeted and actual costs are allocated, are used for evaluating the realization of costs. When determining costs, the primary consideration is the relationship of costs to the cost object, as seen in figure 3.

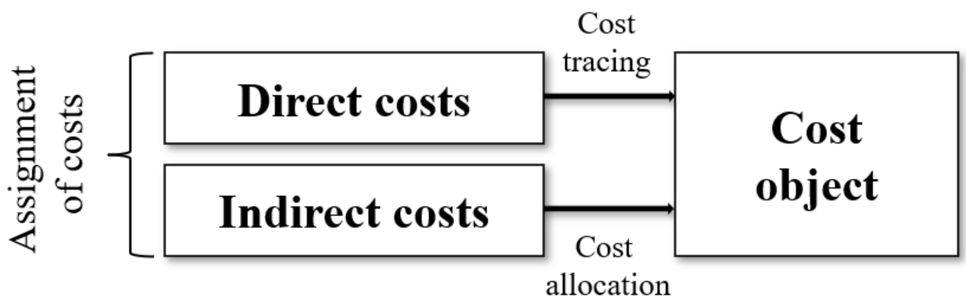

Figure 3: Assignment of costs to cost objects (based on Miller-Nobles et al. 2019, p. 34)

If a cost is directly related to the cost object, it can be termed as a direct or traceable cost. These costs can be allocated to the cost object in a cost-effective and straightforward manner. Costs that are related to the cost object but cannot be directly traced to it are considered indirect or overhead costs in manufacturing. Indirect costs cannot be allocated directly to cost objects, but they can be allocated using estimation methods at one's own discretion (Miller-Nobles et al. 2019, p. 34). There are however regulations and rules that govern cost allocations if they are utilized in stock value calculations or budgeting.

2.2.2 Fixed and variable costs

Costs can be defined in ways other than by examining their relationship to the cost object. It is often also necessary to examine how costs change in respect to changes in the level of activity (Figure 4). This is referred to as cost behavior. Costs can be classified into variable of fixed costs based on their behavior. Variable costs fluctuate according to changes in the level of activity and are often tied to labor hours, production volume, material flows, and sales quantity in manufacturing companies (Garrison et al. 2010, pp. 48–49). Typically, labor and material costs are considered as direct variable costs in the manufacturing industry.

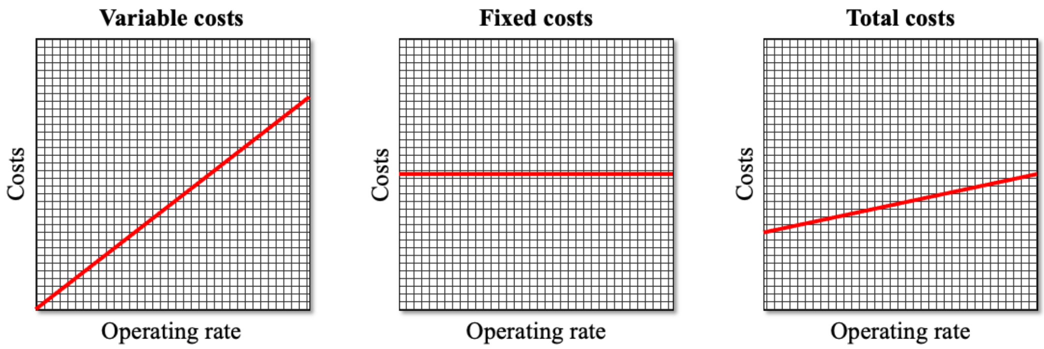

Figure 4: Fixed and variable cost classifications (based on Neilimo & Uusi-Rauva 2012, p. 53)

Conversely, fixed costs remain constant within a certain period regardless of the level of activity. It is worth mentioning that over a long time-period, all costs become variable. Garrison et al. (2010, p. 49) additionally note that only a small portion of costs are entirely fixed during a given period. Typical fixed costs in manufacturing industries include depreciation, leasing and rents, salaries of executive employees, maintenance and cleaning of production facilities, and office supplies (Anderson 2009, p. 67).

2.2.3 Overhead costs

As mentioned before, overhead manufacturing costs can be classified as manufacturing costs that are related to cost objects but can't be traced to them in an economically feasible way. Overhead costs can be classified either as fixed or variable costs depending on their relation to production operating rate fluctuations (Figure 5).

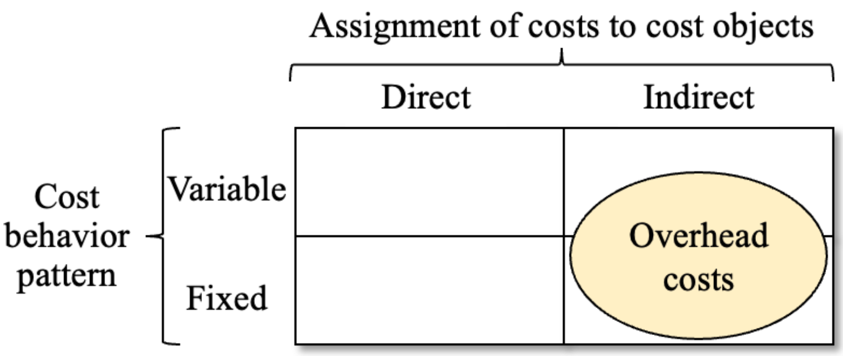

Figure 5: Overhead cost classifications (based on Horngren et al. 2012, p. 56)

In the manufacturing industry, variable overhead costs often include costs related to indirect labor, machine maintenance, spare parts, consumables, and energy. On the other hand, fixed overhead costs include equipment depreciations, rents, office personnel costs and salaries of office personnel. (Horngren et al. 2012, pp. 56–59) Overhead costs can be seen as synonymous with indirect costs in this thesis' scope.

2.2.4 Other costs

Costs related to variable and fixed costs also include separate costs and joint costs. Separate costs can be considered as costs that arise because of conducting a specific activity. They do not occur if the activity is not conducted. All variable costs are separate costs, but separate costs also include a fixed portion.

Joint costs do not arise from individual activities but are rather shared among several activities. Unlike separate costs, joint costs cannot be directly assigned to cost objects in an economically feasible way. They often occur in production processes which involve a lot of variability or different types of activities (Garrison, Noreen & Brewer 2020, p. 50).

According to Drury (2004, pp. 33–58), there are also semi-fixed costs and semi-variable costs, both of which are more or less dependent on the level of activity but not entirely classifiable to either category. A semi-fixed cost could be, for example, a salesperson's salary cost, consisting of a fixed base salary and a variable commission salary. Here the fixed base-salary is the dominant cost type. Conversely, semi-variable costs include, for instance, electricity, heat, and lighting costs, where there is a fixed distribution cost and total costs that vary based on usage. In this example, the variable portion is the dominant cost type.

2.3 Cost types in manufacturing industry

2.3.1 Raw materials and components

Companies use several production factors to manufacture products. Resources such as raw materials, labor, workspaces, and various machines and equipment are essential for production (Neilimo & Uusi-Rauva 2012, p. 84). The resources required for manufacturing can be categorized into four different production factor groups as per table 2.

Table 2: Production cost categories (based on Neilimo & Uusi-Rauva 2012, p. 84)

Production factors	**Cost types**
Raw material and components	• Materials
Work performance	• Labor costs, wages with associated costs
Short-term production factors	• Supply costs • Rental costs • Energy costs • Transportation costs
Long-term production factors	• Depreciations • Insurance • Interests on capital employed

The first production factor group includes raw materials and components, associated with the concept of material costs. Material costs include raw materials, components, semi-finished goods, additive materials, and consumables such as small supplies and lubricants. Material costs are considered to consist of two separate parts: item-specific material quantities and their unit costs (Neilimo & Uusi-Rauva 2012, pp. 89–90).

Material costs exhibit significant industry and company-specific variations. Especially in manufacturing industries, material costs related to the production factor group of raw materials and components often appear as the largest cost type. Manufacturing companies aim to manage material acquisitions according to the production needs through a just-in-time (JIT) approach to minimize storage costs. Material costs are typically determined through inventory accounting, utilizing the basic formula for material and supply usage in retrospective cost tracking as seen in formula 1. (Neilimo & Uusi-Rauva 2012, p. 89; Järvenpää et al. 2010, pp. 76–79).

$$\textit{Starting inventory} + \textit{Acquisitions} = \textit{Consumption} + \textit{End Inventory} + \textit{Waste} \qquad (1)$$

Material and supply usage costs can be valued based on their original purchase price, replacement cost, or standard cost. Various methods, such as First-in-first-out (FIFO) and first-in-last-out (LIFO), weighted average cost, and running average cost, can be used for cost valuation. The choice of valuation method depends on factors like the method's suitability for the business and its simplicity (Neilimo & Uusi-Rauva 2012, p. 93).

2.3.2 Work performance

The primary cost types associated with work performances are direct labor costs and their indirect ancillary costs. The salary cost is the compensation for work performed based on employment contracts, and it includes both direct wages and indirect ancillary costs. Ancillary costs deducted from the gross salary typically include pension contributions, unemployment insurance contributions, health insurance contributions, and fringe benefits (Neilimo & Uusi-Rauva 2012, pp. 84–88).

2.3.3 Short-term production factors

Typical cost types related to short-term production factors include supply costs, rental costs, energy costs, and transportation costs. These cost types consist of separate costs such as purchased energy, representation expenses, telecommunication costs, transportation costs, maintenance, and consulting service costs, as well as costs related to leasing machinery, equipment, and business premises (Neilimo & Uusi-Rauva 2012, p. 95).

2.3.4 Long-term production factors

Acquiring, managing, and ensuring long-term production factors result in capital costs for the company. Capital costs related to the acquisition of long-term production factors include depreciation and interest. Insurance costs related to tied-up capital in inventory are also considered capital costs for long-term production factors. Insurance costs may include fire insurance, liability, interruption, and traffic insurance. The calculation of insurance costs is often straightforward, as the precise amounts are detailed in accounting and distributed over several accounting periods. The capital costs of acquisitions, such as interest and depreciation, are typically handled by allocating the costs over several accounting periods using various methods (Järvenpää et al. 2010, p. 82; Neilimo & Uusi-Rauva 2012, p. 96).

To summarize, this thesis is largely focused on the variable overhead costs which arise due to consumption of material and components, work performances, and short-term production factors, which can be further classified as joint costs that are accumulated from several activities.

2.4 Main challenges of cost accounting

In the preparation and use of accounting reports, careful attention must be paid to the information they contain, as the content and methods of calculation of cost items may vary significantly between companies (Neilimo & Uusi-Rauva 2012, p. 41). The information produced to support decision-making can take various forms, such as qualitative or quantitative, past or future-oriented, and monetary or non-monetary. There are various fundamental problems associated with the information produced by accounting. Users of reports need to be aware of these problems to interpret the information correctly. Fundamental accounting problems generally relate to the produced information and are based on the scope, valuation, allocation, and measurement of costs (Järvenpää et al. 2010, p. 44).

1. **Scope problem:** This problem revolves around the scope of revenues and costs included in the calculations. Companies must decide whether to include only business revenues, leaving out occasional revenues, or include all revenues and costs in the calculations. The resolution of scope problems varies between companies and lacks a standardized solution.

2. **Valuation problem:** The valuation problem concerns the values used in accounting reports. For tangible assets like machinery, historical cost is commonly used in managerial accounting. However, other methods such as current cost or replacement

cost may be used. In different economic situations, variations in valuations can be significant, affecting, for example, the costs of raw materials.

3. **Allocation problem:** The allocation problem consists of two sub-problems. The first is the scheduling problem, which relates to the allocation of long-term production factors' depreciation over several years. The second is the apportioning problem, which involves allocating indirect costs to specific cost objects such as cost centers, customers, products, or services.
4. **Measurement problem:** The measurement problem is about the reliability of the information produced by accounting. It revolves around the accuracy of the registration system in terms of the company's chart of accounts, data collection and measurements.

These problems are inherent challenges in accounting, and their resolutions can vary based on company practices, industry standards, and legal requirements. To correctly interpret managerial and financial reports, an understanding of these challenges must be acquired. In the case of variable overhead allocation through product costing methods, the measurement problem is the most significant constraint. If costs are wrongfully measured or evaluated, the allocations can severely distort product costs.

3 Product costing methods in manufacturing

3.1 Starting points of product costing system development

Kaplan and Cooper (1998, p. 2) note that companies need cost accounting systems for three different purposes: to valuate inventories, to assess cost incurred by activities, products, services, and customers, and to provide financial feedback on the cost efficiency of processes. The information produced by cost accounting systems can be utilized in various ways, such as in product pricing, budgeting, inventory valuation, performance measurements, and customer profitability analyses (Schoute 2009, p. 217). The impulse for cost accounting system development stems from the needs of company management.

According to Schoute (2009, p. 209), when designing cost accounting systems, it’s important to firstly identify which costs will be allocated to cost objects. Both simple and complex cost accounting systems trace direct costs directly to cost objects. Overhead costs however are allocated in various ways based on a company’s own judgement. Drury and Tyles (2005, p. 59-62) note that the level overhead costs incurred from manufacturing and support activities largely determine the complexity of cost accounting systems. If overhead costs are relatively low compared to direct labor and material costs, developing more sophisticated approaches to allocate costs to products might not be worthwhile. On the other hand, if overhead costs are significantly large, as they often are in manufacturing companies, more complex cost accounting systems are needed to eliminate distortions in product costs (Cooper & Kaplan 1988, p. 22).

Reynolds, Fourie and Erasmus (2022, p. 4) as well as Suomala et al. (2011, p. 141) note that the main challenge with complex systems is finding the correct causal relationships and allocation methods. Wrongful choices in the preliminary steps of cost accounting system development can have large negative impacts. This can be classified as a measurement problem according to Järvenpää et al. (2010, p. 44). Figure 6 depicts the relationship between cost accounting system accuracy, complexity, benefits, and costs.

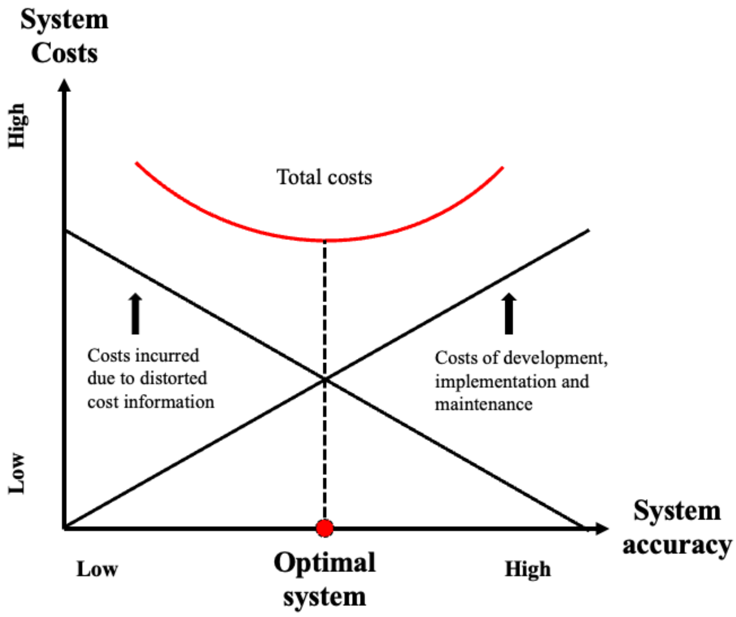

Figure 6: Optimal cost accounting system (based on Hilton 2008, p. 190)

Choosing a suitable costing system approach is always a company-specific task. When developing the system, it's profitability must be assessed by comparing the costs of complexity with the benefits from gained accuracy (Arora 2022, p. 709). An optimal cost accounting system balances the costs and benefits of accuracy, complexity, planning, implementation, and maintenance to find an optimal level for costs and complexity (Hilton 2008, p. 190). Additionally, Neilimo and Uusi-Rauva (2012, p. 113) have listed several requirements for the development of cost accounting systems. Firstly, to satisfy company needs, the developed costing system must be simple enough to understand. It must also be reliable and fast. It also must be updateable in an economically feasible way and must contain important information that can be utilized towards better profitability through data-oriented decision making. The results must also be easily accessible by related stakeholders.

3.2 Traditional product costing methods

Traditional product costing includes methods such as gross margin costing, performance measurements, cost center accounting, allocation accounting, incremental accounting, and standard cost accounting (Raudasoja & Suomela 2014, p. 39). Each approach has its own benefits and drawbacks. However, detailed descriptions of these methods aren't discussed in this thesis. The focus is on examining the main drawbacks of these methods in general.

The basic framework for product costing in traditional approaches follows a simple process. Direct production costs such as material and labor costs are directly traced to products. Overhead costs on the other hand are allocated to products through one or more general factory overhead cost rates. (Huang 2018, p. 55) In all traditional costing methods, overhead costs are typically applied to products depending on operating rates or production volumes (Neilimo & Uusi-Rauva, 2012, p. 144). This simple system of allocating overhead costs to products is easily applicable and effective for companies with few products and homogenous manufacturing processes (Drury 2004, p. 81).

According to Cooper and Kaplan (1988, p. 20), companies need to know their true product costs to make sensible business decisions. Product costs derived from traditional cost absorption methods often fail to correctly assess manufacturing overheads due to their operating rate-oriented nature, resulting in distorted product costs (Cooper & Kaplan 1988, p. 24; Neilimo & Uusi-Rauva 2012, p. 144). Arbitrary overhead cost allocations to products through production levels and operating rates distorts product costs even further as the diversity and complexity of manufactured products increase (Kaplan Financial Knowledge Bank 2020). Other issues with traditional costing systems were also cited by Askarany and Yazdifar (2009, p. 95) as follows: traditional costing systems fail to assess the full picture, data extraction and analysis is laborious, variance analysis is difficult to conduct, and causal relationships are almost impossible to validate. Kitsantas, Vazakidis & Stefanou (2020, p. 163) also note failure to contribute to decision-making through cost precision and inability to modify cost behavior patterns as main shortcomings of traditional costing systems.

3.3 Activity-based product costing methods

3.3.1 Conventional activity-based costing (ABC)

To overcome the limitations of traditional costing systems in increasingly diverse and complex environments, an activity-based costing (ABC) approach must be considered (Kitsantas et al. 2020, p. 161). Conventional ABC is generally seen as the most accurate way of allocating overhead costs according to the principles of causation while also retaining correctness of direct costs (Järvenpää et al. 2010, p. 128). Cohen, Venieris and Kaimenaki (2005, p. 983) list the main attractions of ABC systems to be increased transparency to profitability figures, accuracy in product costs and reliability of budgets. Kitsantas et al. (2020, p. 167) list positive impacts on business performance, support in decision-making, increase in productivity and identification of non-value adding activities as main benefits of ABC approaches.

The goal of activity-based costing is to evaluate the costs of manufacturing activities and using appropriate drivers to allocate these costs further to cost objects such as products and services (Figure 7). The activities in ABC are simply tasks conducted in a company. In the manufacturing industry, activities can be tasks such as machine setup, material preparation, direct labor, equipment maintenance or quality control (Horngren et al 2012, p. 128). Thus, the basic requirement for ABC systems is understanding the activities of a company, comprehending the principles of cost behavior, and identifying the causal relationships between costs, activities, and cost objects (Järvenpää et al. 2010, p. 128).

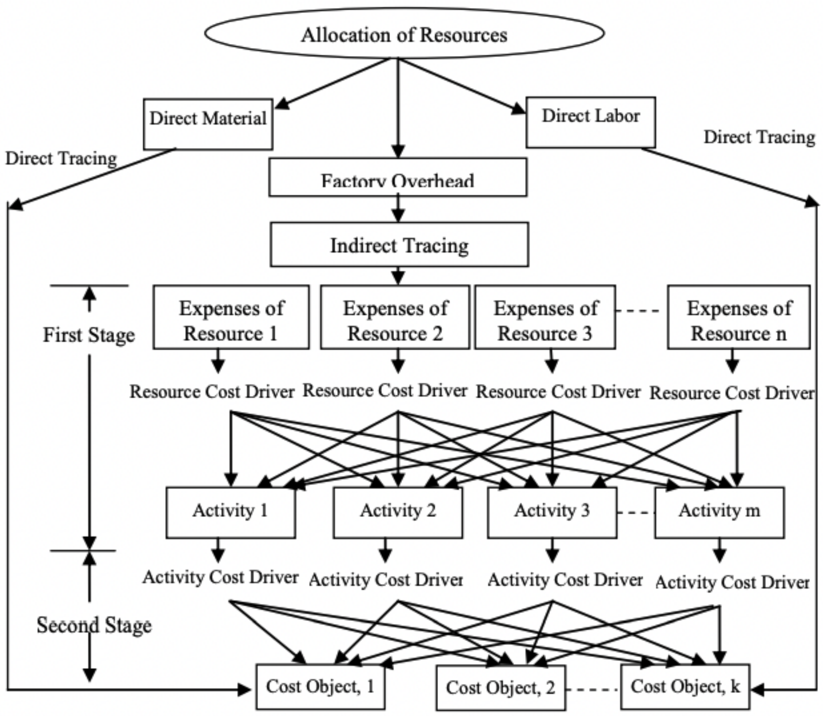

Figure 7: Elements of conventional ABC systems (Namazi 2016, p. 460)

Activity-based costing allocates costs to cost objects in several ways and stages. Direct labor and material consumption are traced directly to cost objects. In manufacturing companies this is conducted through ERP system manufacturing route and product structure information. Factory overhead costs are indirectly traced to resources used in manufacturing often through cost centers or other identifications. In the first stage, resource (cost) drivers are used to trace the expenditure of resources such as materials or time within activities. In the second stage, overhead costs are driven down further to cost objects through (activity) cost drivers. (Namazi 2016, p. 460) Resource drivers and cost drivers are typically determined through estimations and by surveying employees about their time expenditure on various activities (Kaplan & Anderson 2004). Cost drivers are quantitative values which can be directly associated to the cost objects, such as machine run times, working hours, number of batches, or number of orders. Now, the effects of activity costs to products can be directly calculated by multiplying the unit costs of activities by the required cost object quantity. (Neilimo & Uusi-Rauva 2012, p. 152-154; Järvenpää et al. 2012, p. 128-136) Figure 8 provides a simplified view of the main concepts and costing process of ABC.

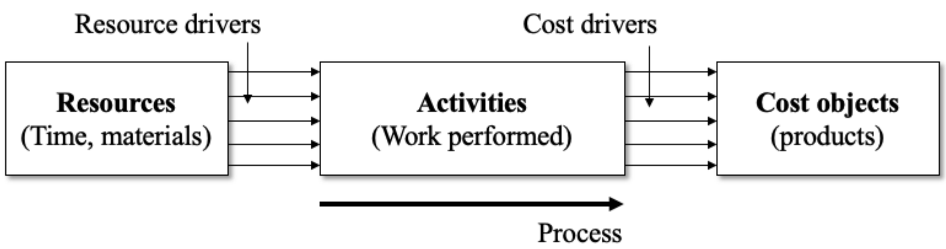

Figure 8: Interrelation between the main concepts in ABC (Kitsantas et al. 2020, p. 163)

From a theoretical viewpoint, ABC looks like a perfect way to allocate overhead costs in a just manner to gain important insight to key product cost and profitability figures. However, although companies that have implemented ABC systems have seen many benefits, the downsides to ABC systems can easily outweigh the benefits. (Kaplan & Anderson 2004) The most influential constraints for ABC systems are seen as system complexity, lack of top management support, employee resistance, technical problems, compatibility issues with other systems and high maintenance costs (Askarany & Yazdifar 2007, p. 95; Tran & Thao 2020, p. 2627). Also, ABC often considers employees to operate at full capacity, resulting in overestimation of cost driver rates (Kaplan & Anderson 2004). Suomala et al. (2011, p. 141) also noted the selection of appropriate cost drivers which adhere to the causal relationships between costs and cost objects to be one of the most difficult tasks in activity-based costing.

Often the true nature of activities in an organization is too complex to capture in its full essence, as quoted from Kaplan and Anderson (2004): “Suppose a company has 150 activities in its enterprise ABC model, applies the costs in these activities to some 600 000 cost objects (products and customers), and runs the model monthly for two years. That would require data estimates, calculations, and storage for more than 2 billion items. Such expansion has caused ABC systems to exceed the capacity of generic spreadsheet tools, such as Microsoft Excel, and even many ABC software packages.”

3.3.2 Time-driven activity-based costing (TD-ABC)

According to Kaplan and Anderson (2004), the root problems with conventional ABC systems arise from the way the systems are constructed. Using employee surveys to estimate the costs of activities works well in limited settings in which conventional ABC was initially developed. However, difficulties arise when the ABC approach is applied on a larger scale.

All in all, the basic framework of ABC should not be abandoned, but it should be enhanced to fit larger and more complex organizations by simplifying the cost allocation structure. The solution is to utilize a time-driven ABC (TD-ABC) approach. In the revised approach, the costs of activities are directly estimated through the resource demands of transactions and products (Cooper & Kaplan 2004). Table 3 highlights the key differences between conventional ABC and time-driven ABC approaches.

Table 3: Comparison of TD-ABC and conventional ABC systems (Hooijer 2023)

Parameters	**TD-ABC**	**Conventional ABC**
Estimation focus	Unit cost of capacity, time required for activities	Activity-specific resource usage
Data collection	Direct observation or managerial estimates	Employee surveys, interviews, time logs
Scalability	High	Low to moderate
Adaptability	Flexible and responsive to process changes	Rigid and prone to obsolescence
Updates	Easily implemented and maintained	Time-consuming and expensive

Instead of having multiple cost drivers and complex relationships, TD-ABC uses time as the primary driver of costs to cost objects and relies on time equations to estimate the resource demands of activities. Using time as the main cost driver simplifies the system in such a way that significant improvements in efficiency, flexibility, accuracy, adaptability, and validation can be noted (Hooijer 2023). Also, the underlying false assumption of 100 % capacity utilization in traditional ABC can be eliminated (Kaplan & Anderson 2004). Additionally, Areena and Abu (2019, p. 20) highlight supporting operational improvement, capturing costs accurately, managing complexity and overall simplicity as the main benefits of utilizing a TD-ABC approach. Figure 9 illustrates the basic principles of traditional costing, ABC and TD-ABC.

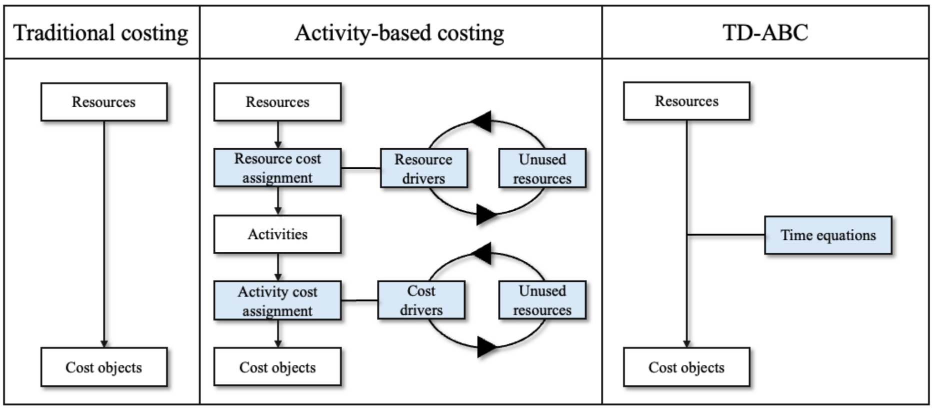

Figure 9: Traditional and activity-based costing methods (based on Kaplan & Anderson 2004; Namazi 2016)

The TD-ABC approach firstly identifies the capacity and costs of processes and activities. Then, the TD-ABC system allocates activity costs to cost objects based on the time required to perform one cost object's worth of activity (Monroy, Nasiri & Pelaez 2014, p. 3). According to Evaert and Bruggeman (2007, p. 17) and Areena and Abu (2019, p. 18), determining the unit cost of deliverables through a TD-ABC approach consists of 6 key steps (Figure 10).

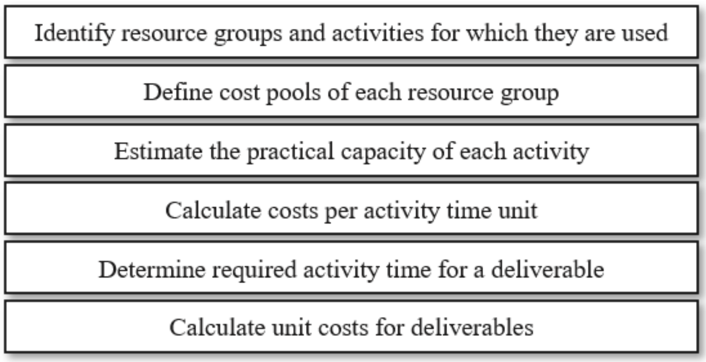

Figure 10: TD-ABC unit cost calculation steps (based on Evaert & Bruggeman 2007, p. 17; Areena & Abu 2019, p. 18)

The application scope of TD-ABC doesn’t significantly affect the calculation of unit costs. Essentially, regardless of whether TD-ABC is used to calculate product costs or service costs, the 6-step process remains intact. Furthermore, this indicates that TD-ABC is applicable in a similar fashion in both service and manufacturing industries and is a method of aggregating total costs of personnel, equipment, and consumed materials to come up with a total cost of deliverables.

Although sources such as Kaplan and Anderson (2004) emphasize TD-ABC as a near-perfect solution for the shortcomings of conventional ABC methods, Namazi (2016, pp. 471-475) notes that TD-ABC also suffers from similar drawbacks as conventional ABC systems:

- Using time as the sole cost driver can limit the accuracy of fixed overhead cost allocations.
- Inaccuracy in depicting causal relationships between costs, activities and cost objects can distort product costs.
- Challenges in determining practical capacity costs can create issues in cost driver accuracy and therefore product cost information.
- Data collection requirements are still significant, similar to traditional ABC systems. Especially fixed overhead cost allocation still requires some form of surveying to assess the link between resources and activities.
- TD-ABC presumes a linear relationship between resources and activities, which may not hold when assessing complex processes.

These constraints must be carefully considered when examining the applicability of TD-ABC systems in industrial environments. Although some of the issues can be resolved through sufficient cost analyses prior to time driver calculations as well as through utilization of digital systems, some constraints will remain. These remaining constraints must be brought to knowledge to set an acceptable level of reliability for the cost data produced by the system. From the thesis' viewpoint, TD-ABC is the most adaptable approach to product costing in the selected manufacturing company, as its current ERP system contains all the necessary data needed to develop an automated allocation system that allocates overhead costs based on production time. Using various other specific cost drivers in conventional ABC defeats the purpose of having a simple, updateable system, as the ERP doesn't contain enough data to support such allocations – resulting in having to utilize an independent allocation system which is not aligned with the company's interests.

3.4 Prevalence of conventional ABC and TD-ABC in scientific research

To summarize, the empirical studies regarding TD-ABC approaches are scarce. According to Izquierdo et al. (2023, pp. 51-54), 148 papers on TD-ABC approaches in disciplines such as medicine, business management, engineering and economics were published during 2008 to 2022. The most significant fields of knowledge were medicine, business, and management accounting with few publications directly associated with manufacturing. In comparison, research related to conventional ABC is significantly more accessible, with authors such as Sáncher-Rebull, Niñerola and Hernández-Lara (2023, p. 1) examining more than 1260 ABC-related articles from 1988 to 2019 in their literature review. A TD-ABC study conducted by Areena and Abu (2019, pp. 15-16) assessed 56 published works from 2011 to 2018 and concluded that TD-ABC was mostly studied in healthcare sectors with 66 % of studies related to the field. Only 23 % of TD-ABC research was related to the industrial field. In contrast, research conducted by Namazi (2016, pp. 466-471) found that both conventional and time-driven ABC approaches have been implemented mostly in manufacturing companies with some findings of service industry applications.

In research conducted by the Chartered Institute of Management Accountants CIMA (2010, pp. 7-11), 439 respondents globally were surveyed about their current usage of management accounting tools. Of the respondents, 136 were in the manufacturing industry. Figure 11 showcases the findings of costing tool usage in respondent organizations.

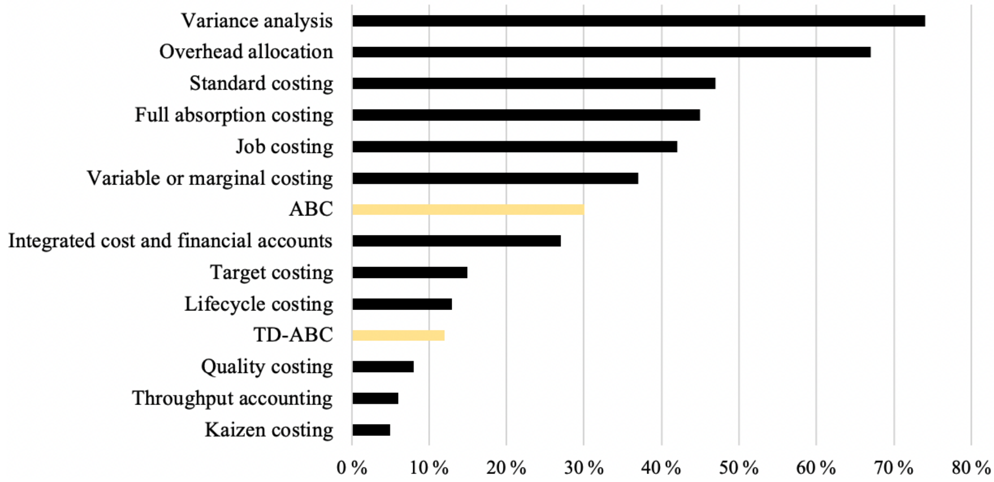

Figure 11: Relative popularity of costing tools (based on CIMA 2010, p. 11)

The research indicated that a wide range of costing tools were used in organizations, with traditional tools of overhead allocation being the most significant method for cost accounting. Only 30 % of respondents utilized ABC as a tool for overhead costing, and 12 % utilized TD-ABC. Both approaches were similar in usage throughout small, medium, large, and very large organizations. It is worth noting that the research is currently almost 15 years old, and it is likely that significant advancements in costing approaches have arisen during this period, possibly elevating the level of adaptation of TD-ABC approaches. No newer studies of similar fashion were found to assess the development of costing methods in different sectors and organizations.

A study conducted by Pierce and Brown (2006, pp. 117-118) noted that 27.9 % of respondents in the manufacturing industry reported having an ABC system for product costing, with 9 % of respondents reporting that they were still considering an ABC approach. When it comes to TD-ABC approaches, research on the adoption rates within manufacturing industry is not easily accessible. However, Kaplan and Anderson (2004) cited helping more than 100 clients with overhead cost allocations through a TD-ABC approach in 2004. Kaplan and Anderson (2007) also claimed the successful implementation of TD-ABC in more than 200 manufacturing firms in 2007.

3.5 Development process of TD-ABC product costing systems

Gunasekaran (1997, pp. 118-124) and Kaplan and Anderson (2007, pp. 60-73) break down the development process of activity-based costing systems in manufacturing companies into distinct phases (Figure 12). Kaplan and Anderson discuss TD-ABC directly while Gunasekaran focuses on conventional ABC systems. Findings from both sources have been combined and modified slightly to fit the process of a TD-ABC overhead cost allocation approach. Before the development of product costing systems, the justifications for development must be identified. Gunasekaran (1997, p. 118) lists three main reasons for transitioning from traditional costing systems towards an activity-based approach:

1. The current costing system is inaccurate.
2. The current costing system doesn't encourage improvement.
3. Overhead costs are predominant.

A beneficial costing system should firstly aim to accurately depict product costs to measure customer profitability. Costing systems should also aim to align the organization towards better profitability and manufacturing efficiency through sufficient information especially regarding manufacturing overheads. This information can be used to determine the value-adding activities of management personnel and support functions.

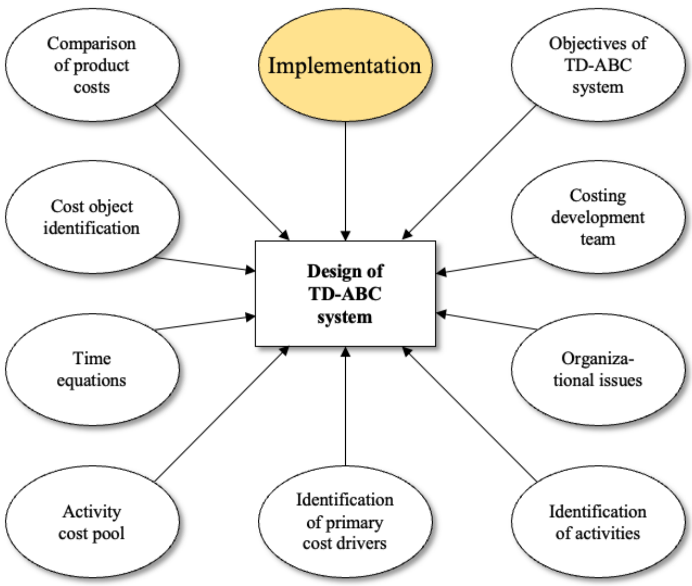

Figure 12: Design of activity-based costing systems (based on Gunasekaran 1997, p. 121)

Firstly, the objectives of a TD-ABC system must be identified. It’s important to select the specific needs within the company as main drivers for costing development. A costing development team must be assembled to guide the development process to create clear ownership for the system development. The costing development team should include both financial and operative knowledge regarding the company’s cost structure and manufacturing processes. Organizational issues must also be addressed to create clear boundaries for the system. This means closely examining the structure of processes and activities, expenditure of resources and status of internal reporting for instance. Cost-incurring activities should be identified and grouped according to their expenditure of resources. In manufacturing companies, this can mean grouping similar production processes into activity groups. Next, the costs associated with activities should be identified. This essentially means linking costs to activities through analyzing the general ledger and transaction data from a company’s accounting or ERP system. Through cost and activity association, activity cost pools can be formed. The activity cost pool is the total cost associated with each activity. The time equations for matching activity costs and cost objects are formed based on incurred costs and time expenditure of activities. Let’s say the yearly variable overhead costs for machining were 100 000 € and 5 000 direct labor hours were spent on machining, the cost driver for machining is 100 000 € divided by 5 000 hours, resulting in a time driver of 20 € per direct labor hour. Next, the cost objects are identified. In manufacturing these are often individual products. To evaluate the costs from traditional product costing and TD-ABC, simulations of cost allocations are conducted, and the results are compared with existing product cost data. If the costing development team is satisfied with the solution, the implementation phase can begin. (Kaplan & Anderson 2007, pp. 60-73; Gunasekaran 1997, pp. 118-124)

Kaplan and Anderson (2007, p. 60) have created an additional model for the practical implementation process of TD-ABC systems (Figure 13). The implementation process consists of 4 key phases: preparation, analysis, pilot model construction and rollout of the system. The preparation phase contains many of the same elements as Gunasekaran’s development process framework, but the remaining phases are more focused towards the practical tasks related to implementing the system across the organization.

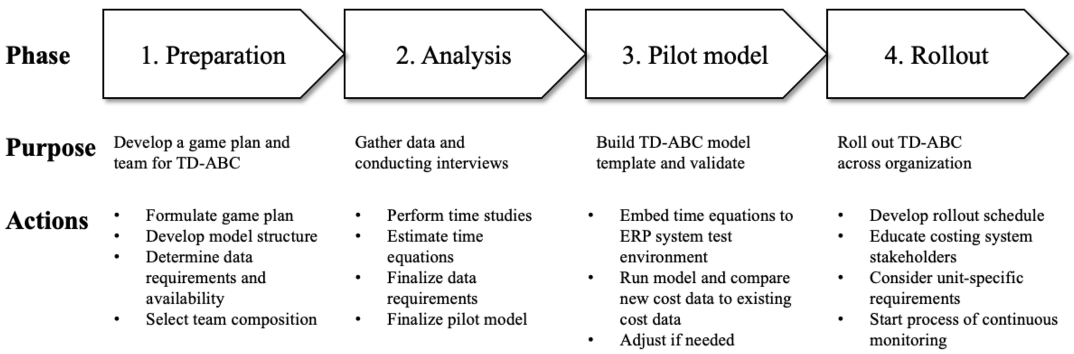

Figure 13: TD-ABC implementation model (based on Kaplan & Anderson 2007, p. 60)

In the preparation phase, the general boundaries for TD-ABC system development are examined. A team for managing the development and implementation process is composed. The availability and requirements of data are assessed, and a model structure is created. In the analysis phase, data is gathered and interviews with costing system stakeholders are conducted. Any corrections or adjustments to the data are made. Time equations are estimated based on finalized financial and operative data. In the third phase, a pilot model for TD-ABC is constructed. The time equations are embedded to a test environment in the ERP system and calculations are executed. Cost results from the TD-ABC approach are compared to existing cost data, and any deviations are noted. Final adjustments to time equations can be made based on the findings from this analysis. When a final, validated pilot model has been constructed, the final phase begins. In the final rollout phase, the goal is to develop a rollout schedule for the costing system. Stakeholders are educated on the purpose, functionality, and benefits of the system. Any unit-specific requirements are considered, and the costing system is adjusted accordingly. After launching the new costing system, the process of continuous monitoring and further development begins. This entails systematic costing status reviews with stakeholders and creating a costing system steering committee to ensure strategic goal fulfillment. (Kaplan & Anderson 2007, pp. 60-72)

3.6 Variable costing and full absorption costing

In addition to various product costing methods, such as traditional and activity-based costing, it’s important for manufacturing companies to consider the method of inventory costing to determine the most suitable approach. According to Horngren et al. (2012, p. 323) and Tuovila (2024), the most common methods of costing inventories in manufacturing companies are variable costing and (full) absorption costing (Figure 14). The main difference between these methods is their consideration of operating-rate independent costs when calculating unit costs for items. Both methods of inventory costing can utilize traditional forms of costing or activity-based product costing (Tenhunen 2013, p. 12-18).

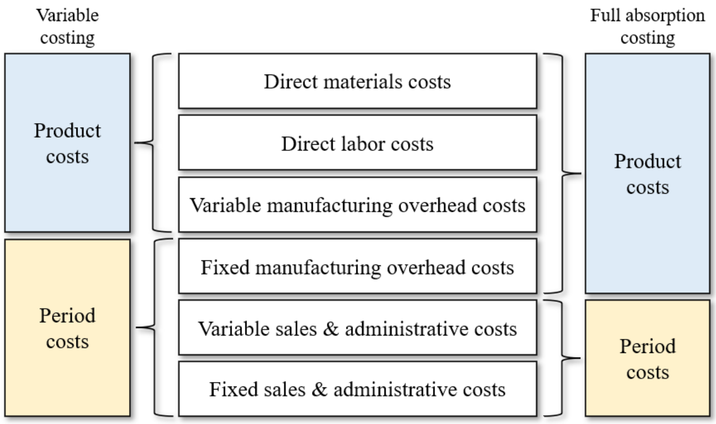

Figure 14: Inventory costing methods (based on Tuovila 2024)

Variable costing considers all variable manufacturing costs as inventoriable costs. This means that variable overhead costs are also included in inventory value. In manufacturing companies, this means product-level inventory costs include costs of materials and labor as well as allocated costs of consumables, electricity, spare parts, and maintenance. Fixed costs related to manufacturing such as depreciation, executive salaries, rents, and leasing are excluded from inventories and treated as period costs from which they incurred. (Horngren et al. 2012, p. 324) Variable costing is typically used for management decision-making and planning purposes due to its accurate representation of incremental costs of producing an additional unit of a product (Tuovila 2024). Full absorption costing differs from variable costing in its approach of allocating fixed overhead costs to each unit of a produced item within a period, regardless of if the item was sold during the period (Tuovila, 2024). Full absorption costing therefore considers all variable and fixed manufacturing costs as inventoriable costs. Other fixed costs not related to manufacturing are still recorded as period costs when they incur (Horngren et al 2012, p. 324). A full absorption approach is typically used for external reporting purposes when calculating the COGS (cost of goods sold) in financial statements (Tuovila 2024).

3.7 Summary of theoretical findings

The purpose of this chapter is to consolidate the core theoretical findings to successfully incorporate the most effective practices in the development and utilization of a TD-ABC system. Firstly, using DSR as a methodological foundation facilitates the integration of theoretical knowledge and industry expertise. This approach supports the construction of a comprehensive TD-ABC development network which considers managerial, organizational, and technical dimensions, ensuring that the system's development is well rounded and grounded in practice.

The imperative for accurate cost allocation is the most important piece of theoretical knowledge. Traditional costing methods have been identified as inadequate for the dynamic and complex nature of manufacturing operations, leading to severe distortions in product costs and furthermore, unreliable decision-making data. The transition to TD-ABC system is motivated by the need for more accurate, causation-based variable overhead cost allocations which are directly tied to costs of manufacturing activities and thus aligning with the principles of causation more closely than traditional methods. The literature review highlights the evolution from conventional ABC methods to time-driven ABC methods due to a simpler and more dynamic approach. TD-ABC's reliance on time equation to estimate the resource demands of activities provides a more straight-forward and accurate method for allocating costs in the case company's complex manufacturing environment. An additional perk of the TD-ABC approach is direct integration with the company's ERP system to increase automation, updateability, and dynamic responsiveness. It is however necessary to remember the issues identified with TD-ABC to also consider them in the case company's development process. Lastly, the nuances of discussed variable costing and full absorption costing approaches are necessary to understand the scope and meaning of developing the TD-ABC system further to incorporate fixed overhead costs to stock allocations.

In summary, the theoretical exploration aims to lay out a solid foundation for understanding the imperatives, methodologies, and challenges associated with developing a TD-ABC system in the chosen manufacturing company. The transition to the empirical application is informed by these insights, enabling a comprehensive and critical examination of the practical implementation and its outcomes.

4 Case company costing overview

4.1 Case company introduction

The empirical research focuses on a specific company in the Finnish manufacturing industry. The company is a large manufacturer of various concrete connections and composite structures for the construction industry. The company consists of a parent company and several manufacturing and sales subsidiaries across the world. The parent company is a management and support entity which controls the subsidiaries and guides strategic and operational decision-making of the organization.

In recent years, the company has invested into developing its information systems through implementing a new ERP system and various supporting systems for internal reporting, product information management, financial administration, and quality control purposes. The company has a vested interest of improving its efficiency and profitability through modern information-technological systems and data-led decision making.

The case company's product portfolio is large, featuring tens of product families which are further divided into hundreds of individual products and again into thousands of inventoriable items which consume organizational resources in uneven proportions. Currently, a variable costing approach is used in product cost accounting, meaning that the inventory value of products consists of direct costs and allocated variable overhead costs. The current methods of allocation rely on traditional costing methods where overhead costs are calculated based on general allocation formulas and are not included in stock value.

From an ABC viewpoint, a very complex costing system would be needed for accurate variable overhead allocations. However, a time-driven approach can very effectively simplify the causal relationships between overhead costs and cost objects by utilizing time-based cost drivers. The TD-ABC approach is made possible by technical features of the new ERP system. Postings made to the ERP system are synchronous with physical processes, which enables real-time monitoring of working hours, thus producing correct direct time consumption to production orders (Figure 15). This feature effectively eliminates the noted issue of inaccuracy in practical capacity estimations regarding TD-ABC time equations.

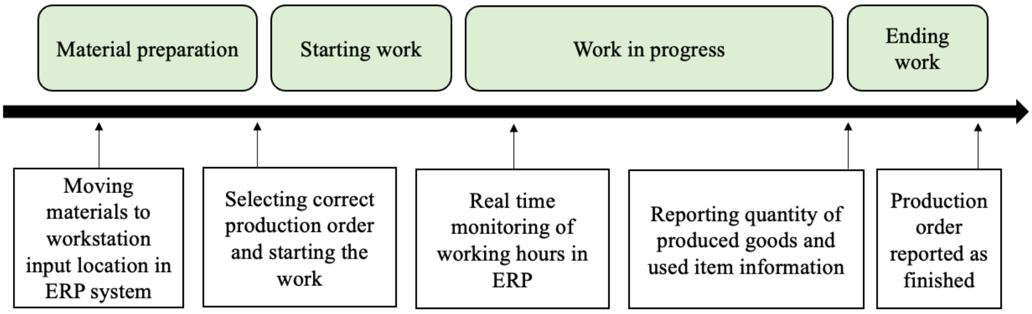

Figure 15: ERP posting principles in the case company

In addition to having visibility to the hours used directly in manufacturing processes, any time not used in active production order-related work is always posted as indirect labor with appropriate reason codes. Material usage and inventory movements are also tracked through scanning identification barcodes on product batches and pallets and registering them into the system at time of production posting. Successful production postings require workers to consume the correct materials from correct pallets in correct locations. This creates an opportunity for full cost and material traceability from end-products to raw materials.

The TD-ABC costing system can be directly integrated to the existing ERP system without any additional costs from added complexity, system compatibility, implementation, or updating from the ERP system standpoint. Through direct integration to the ERP system, overhead costs can also be successfully allocated directly to the stock value of goods in compliance with accounting regulations. It is worth noting that there are costs related to adjusting the financial and managerial reports to correctly display overhead costs allocated through the system, but overall, the development costs are reasonably low.

4.2 Cost structure of the case company

4.2.1 Direct manufacturing costs

In the case company, costs can firstly be split to fixed and variable costs depending on their cost behavior pattern. Costs can also be grouped into direct and indirect costs by their assignment of costs to cost objects. The indirect costs can be classified as either fixed or variable overhead costs. Cost classifications of the company are demonstrated in figure 16.

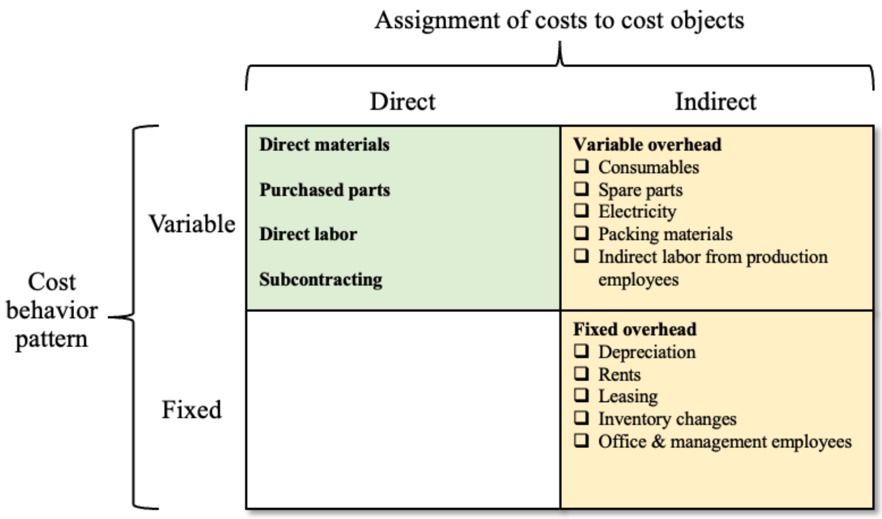

Figure 16: Case company cost classifications

As seen from the above image, the company only has variable direct costs. Direct costs are classified as costs which can be directly seen in the price of products through material or labor consumption. All direct variable manufacturing costs can be directly traced to product level through the ERP system (Figure 17). Overall, the direct costs of manufacturing can be grouped into direct materials, direct labor, purchased parts and subcontracting work.

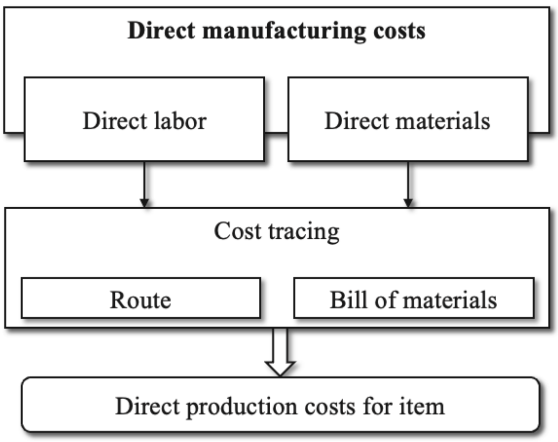

Figure 17: Direct cost tracing in case company

All manufacturing activities revolve around production order routing hierarchy and detailed information of product bill of materials (BOMs). In short, nothing is produced without following correct procedures regarding direct labor hour postings and material expenditure.

Production route setups are conducted backwards, finish-to-start. For example, with standard make-to-order (MTO) items, when customer orders come in, the end-product quantity and shipping date are confirmed. Production planning then automatically creates a hierarchical structure of production orders and sub-production orders for all required components. Each component has its own production order which is linked to an individual workstation's production schedule. All items also have distinct bills of material which contain information about the needed components and their quantities. Therefore, all direct labor and material costs can be accurately traced to finished goods according to realized hours. A weighted average inventory valuation method is used to level out batch cost differences.

4.2.2 Variable manufacturing overheads

Variable overhead costs include material, labor, and service costs not directly visible in production order routing or product bills of material. All variable overhead costs are divided into separate procurement categories and have individual accounts in the company general ledger (Table 4).

Table 4: Variable overhead procurement categories in case company

Procurement category	Category description
Machine maintenance, services, and spare parts (IVC)	Spare parts for production machinery, maintenance services.
Welding filler materials (IVC)	Wires, sticks, rods, fluxes, and powders.
Gas for production (IVC)	Argon, oxygen, nitrogen. Only gas used in production.
Paint & other chemicals (IVC)	Paints, sprays, machining liquids etc.
Packing materials (IVC)	Wooden package, cardboard, plastics, stickers etc.
Workstation equipping & services (IVC)	All tools, tables, conveyors, pens, installation services needed in workstation etc.
Electricity (IVC)	Electricity used in production.
Working clothes (IVC)	Purchases, rents, and services related to working clothes.
Personal protective equipment (IVC)	Shoes, safety glasses, ear plugs, welding helmets, hard hats, gloves etc.
Consumables (IVC)	Drills, abrasives, saw blades, cutting blades, welding nozzles etc.
Warehousing costs (IVC)	Rents of forklifts, costs related to company owned trucks, also fuel. External labor and services related to warehousing.
Waste (IVC)	Waste management services.

Variable overhead costs are costs incurred as a part of manufacturing. They include costs from procurements such as machine maintenance costs, welding filler materials, gases, paints, packing materials, working clothes and warehousing. Variable overheads are not truly fully variable as they contain procurements which are independent of operating rates, but the case company considers all above-mentioned procurements as variable overhead costs.

4.2.3 Fixed manufacturing overheads

Fixed manufacturing overheads are costs incurred from the support and management of manufacturing. They include costs of office and management personnel salaries, machinery, and plant depreciations, rents, equipment leasing and inventory changes. Theoretically, inventory changes can be classified as semi-fixed costs since they contain costs incurred from inventory value fluctuations due to writeups and write-offs which are in some ways related to operating rates. However, the case company classifies this cost type as fixed. The proportion of each cost type in relation to total manufacturing costs can be seen in figure 18.

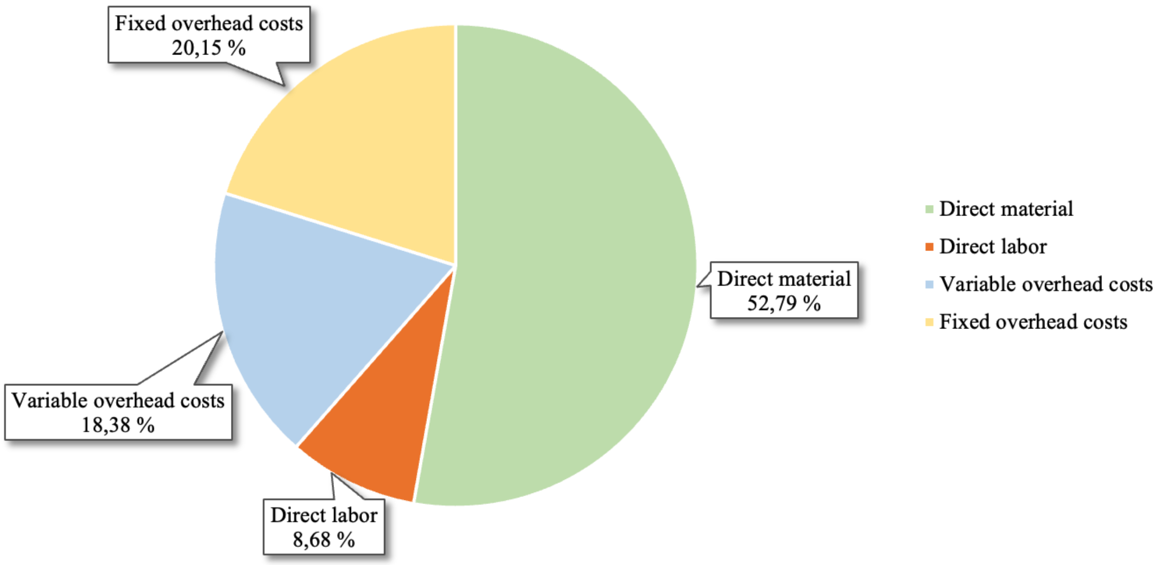

Figure 18: Manufacturing cost types in the case company

To summarize, direct labor and material costs are the most significant drivers of manufacturing costs at almost 62 % of total costs. Variable overhead costs account for 18 % of total costs and fixed overheads for the remaining 20 %. Overall, the combined overhead costs form nearly 38 % of all manufacturing costs, which has a significant impact on product costs in full absorption costing where all manufacturing costs of products are considered. The impact is also significant in a variable costing approach in which only the fixed overheads are excluded from product unit costs.

4.3 Drivers for costing system development in the case company

4.3.1 Challenges and shortcomings in product costing

The case company is experiencing difficulties in matching figures from financial and managerial reports, especially regarding product sales margins due to the current variable overhead cost allocation methods (Table 5). Essentially, the difference between managerial and financial reports is a direct symptom of not allocating overhead costs to semi-finished and finished product stock values, as they account for over 18 % of manufacturing costs.

Table 5: Comparison of financial and managerial report sales margins in the case company

Financial reporting	Managerial reporting
Turnover (invoicing + projects)	**Turnover (invoicing + projects)**
- Direct production costs (COGS)	- Direct production costs (COGS)
Direct materials (BOM)	Consumed materials (BOM)
Direct labor (route consumption)	Direct labor (route consumption)
Product margin	**Product margin**
- Indirect costs (actual)	- Indirect costs (reporting only)
Indirect labor (payroll)	Standard item cost table
Indirect materials (invoice)	Purchased item cost table
Sales freight costs (invoice)	ERP pricing extension
Other project costs (invoice)	Additional allocation methods
Sales margin	**Sales margin**

While direct production cost figures and product margins match together well, issues in comparability arise when looking at the sales margin. In managerial reports, the cost of goods sold (COGS), accrued from consumed material, purchased items, scrap and route times is deducted from the turnover to form a product margin. The same applies for financial accounting reports. As for the sales margin in financial reports, invoiced variable overhead costs such as payroll indirect labor costs, indirect material costs and sales freight costs are further deducted from the product margin to form the sales margin. Managerial reports, however, do not deduct invoiced overhead costs from the product margin due to the limitations set by the current product costing system. The managerial reports rely on manually calculated overhead costs as placeholder figures. In total, there are currently six different ways to calculate and display indirect costs for sold items in managerial reports, according to information fetched from ERP transactions and sales orders. Figure 19 showcases a flowchart of the indirect cost and sales margin reporting logic in managerial reports.

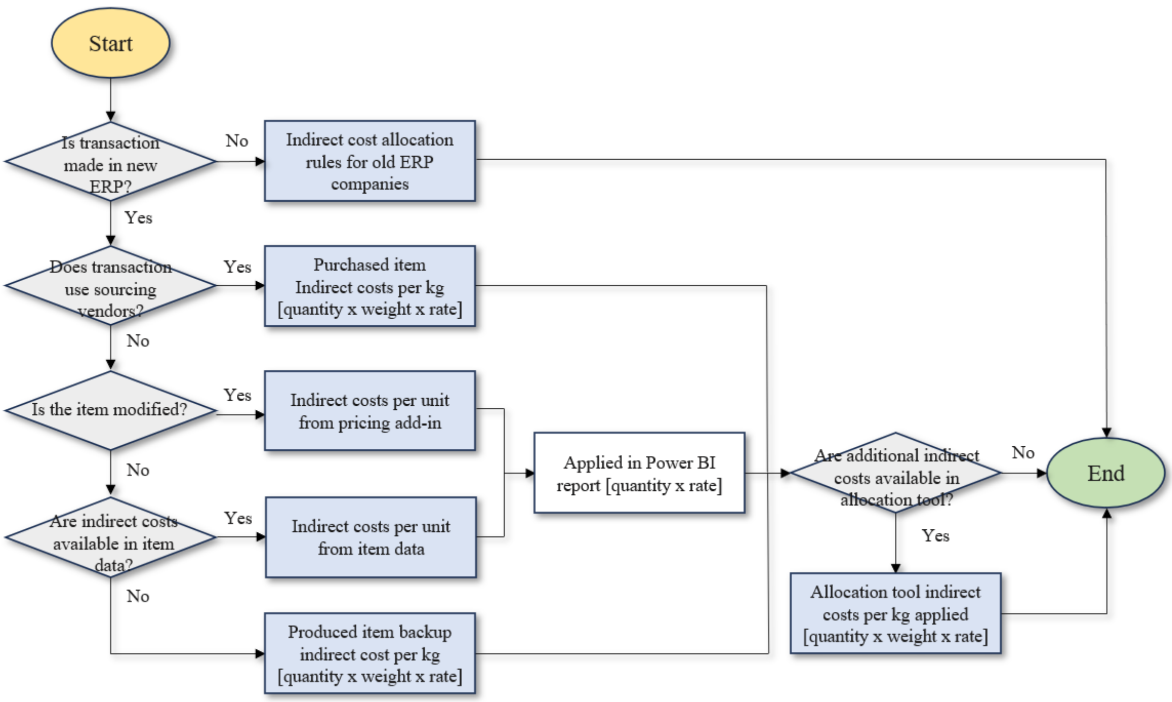

Figure 19: Case company's internal reporting logic for variable overhead cost allocation

When displaying costs for sales order lines in internal reporting, the logic first checks whether the unit is within the domain of the new ERP system. If not, rules for old ERP units are used. If yes, the sales order lines are checked to see if a sold item was produced by the unit or bought from other units internally. If the item was bought, indirect cost rates per kilogram are fetched from the purchased item overhead cost table. Next, the logic checks to see whether an item is modified or standard. If it is modified, the ERP extensions pricing module is used to calculate indirect costs per item which is multiplied by sales quantity. With standard items, a similar approach is used where indirect unit costs are fetched from item data and multiplied by sales quantity. If no indirect costs are present, a backup table with indirect costs per kilogram is used. Lastly, a check is made to see if the sold item has other indirect costs to consider. If not, the existing values are displayed directly in the sales report. If yes, the indirect cost rates per kilogram are fetched from the additional allocation tool and multiplied by sales quantity and unit weight.

The company has developed a controller report for assessing the differences between key figures in both managerial and financial reporting which are assessed monthly after financial closing has been completed. The controller report is used for several purposes, but most importantly to assess the accuracy of current overhead cost allocation rates and the impact of allocations each month. The difference between managerial and financial sales margins largely guides the process of updating current overhead cost allocation rates. To exacerbate, if the difference is close to 0, the cost drivers are not changed. If differences arise in either direction, the allocation rates are fine-tuned accordingly, and the process is renewed iteratively each month for every unit. On a group scale, the difference is in the negative direction, meaning costs are systematically under allocated, resulting in inflated sales margins in managerial reports.

The current overhead cost allocation and reporting system has been developed over many years and is becoming increasingly complicated. An inexperienced user will not be able to explain the logic behind the report or explain why sales margins appear as they are. Therefore, a more transparent and standardized costing approach is paramount.

4.3.2 Goals of costing in the case company

The company has a common goal of making better business decisions via reliable sales margins and comparability between managerial and financial figures (Figure 20). Comparability of production costs among units through standardized costing procedures was also seen as a key driver for facilitating better operative and strategic decision-making. More accuracy in product costs as well as minimal manual labor for variable overhead allocations were also outlined as important goals in costing. In addition, moving towards IFRS IAS 2 accounting standard compliant inventory valuation, where all manufacturing overheads are allocated stock value was listed as an important long-term goal for the company.

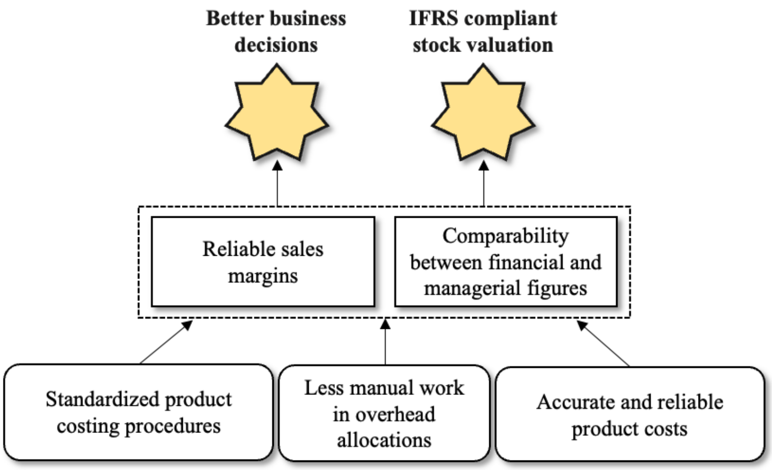

Figure 20: Costing objectives in the case company

5 Developing a TD-ABC system for variable overhead allocation

5.1 Starting points for developing a TD-ABC system in the company

5.1.1 Mapping costing system objectives and assembling a development team

The starting point for developing a TD-ABC product costing system was identifying the objectives of the system, which were ultimately related to making better business-decisions through reliable product cost data and moving towards IAS 2-level inventory valuation through allocating overhead costs to stock. Next a costing development team was assembled. The costing development team consisted of mostly business controllers and operations controllers from both the parent company and various subsidiaries. The costing development team was assembled to take ownership of the development and guide the process to provide sufficient management support. Meetings were conducted with ERP consultants to determine the data requirements and availability for the system. Next, financial advisors were consulted about any possible constraints of allocating overheads to stock value using the TD-ABC system. After assessing that the development was possible, a deeper look into the organizational issues related to product costing and reporting were conducted. Then, the decision of what overheads to allocate was made. To keep the scope of the development manageable, a decision was made to focus on the variable overhead costs displayed in table 4. Fixed overhead allocations will be considered after successfully implementing the TD-ABC system across all units and validating the accuracy and reliability of variable overhead cost allocations. Fixed costs are discussed in more detail in chapter 6.3.

5.1.2 Identifying activities and activity cost pools

After formulating the basic objectives of the system, a preliminary structure for the system was created. Firstly, the manufacturing activities were assessed to form the basis of activity cost pools. A wide range of different activities were identified in the manufacturing processes. To accurately depict the relationships of activities and costs, activities were grouped according to their manufacturing process types (Figure 21).

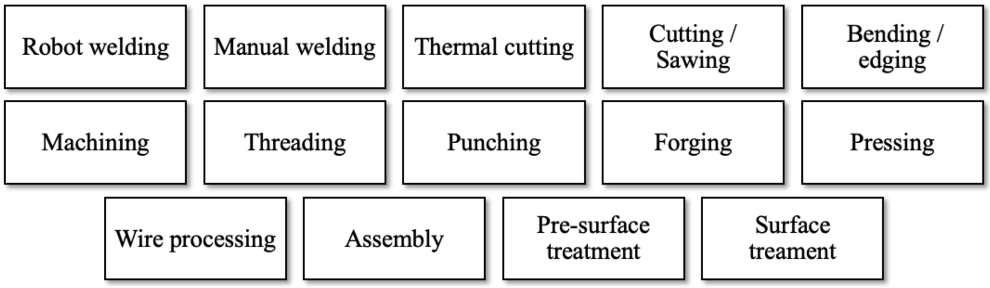

Figure 21: Manufacturing activity groups

A total of 14 activities were identified in the production processes of all units of the company. Every unit does not have the same number of activities; hence the TD-ABC system structure must be slightly altered depending on the unit in question. Overall, the grouping of activities according to their process type was seen as a fair way to allocate costs further from activities to cost objects due to the similar nature of processes within the groups.

After identifying the manufacturing activities, an assessment of the variable overhead costs was conducted. This meant extracting the general ledger account postings for variable overheads and examining their relationships to manufacturing activities. The variable overhead cost categories were firstly split into five cost pools: welding costs, painting costs, packing costs and other overhead costs (Figure 22). Indirect labor was also classified as its own cost pool. All the cost pools have separate general ledger accounts. The classification to 5 cost pools was done to simplify the later process of formulating cost drivers associated with these cost pools. Also, the classification was justified due to the significance of variable overhead costs. Welding, painting, packing, and indirect labor costs formed the majority of variable overhead costs while the remaining categories had a smaller impact.

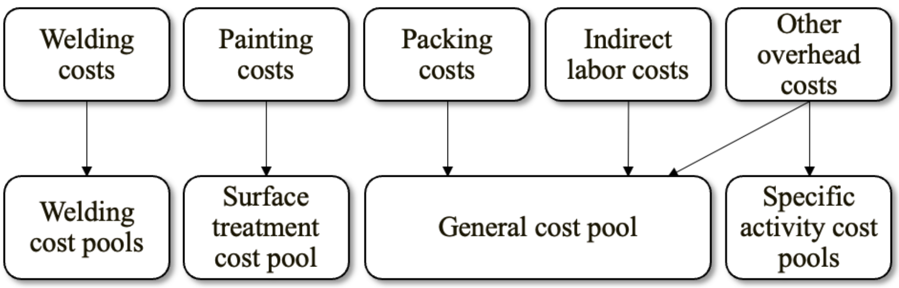

Figure 22: Formation of TD-ABC activity cost pools

Next, the relationships between variable overhead costs and activities were assessed to determine the activity cost pools. Procurements for welding materials could directly be linked to the welding cost pool. A similar approach was possible for painting costs, which were directly linked to the painting cost pool. Packing costs are related only to internal use of pallets, collars, and plastics. They are generally small, thus being evenly distributed to a general activity cost pool. Indirect labor costs were also handled through a general activity cost pool for all activities in the preliminary approach. Other overhead costs such as machine spare parts, consumables, workstation equipment, working clothes and protective equipment are allocated through two drivers. Firstly, the specifying information on invoices directs any possible costs to the activity cost pools of specific activities. For example, if machine spare parts are bought for a forging workstation, they are allocated to the forging cost pool. Costs from procurements such as electricity, waste and warehousing rarely feature any activity-specific information and are therefore allocated to the general activity cost pool.

5.1.3 Calculating time drivers

The process of determining time drivers through the activity cost pools and practical capacity usage was made simple due to the features of the ERP in which hourly posting is conducted in real time, synchronously with manufacturing processes. Determining practical capacity usage was a non-issue and helped the development process tremendously. Identifying cost objects was also a simple process due to the systematic structure of the ERP system. The company only manufactures physical items, and all manufactured processes are also digitally simulated within the ERP system. This means that the tracing of activity costs to cost objects was made simple through assessing the practical capacity (realized labor hours) expended in each activity to produce products.

The cost drivers were formulated using information from the ERP system gathered to a Power BI-based reporting system. A connection to Qlikview reporting was also used for some of the financial information. The gathered data from was then examined combine the practical capacity usage of activities along with the costs associated with activities to calculate the necessary time drivers. The time drivers were calculated in an Excel-template and imported as quantitative values directly to the TD-ABC module within the ERP system. Figure 23 illustrates the process of determining time drivers.

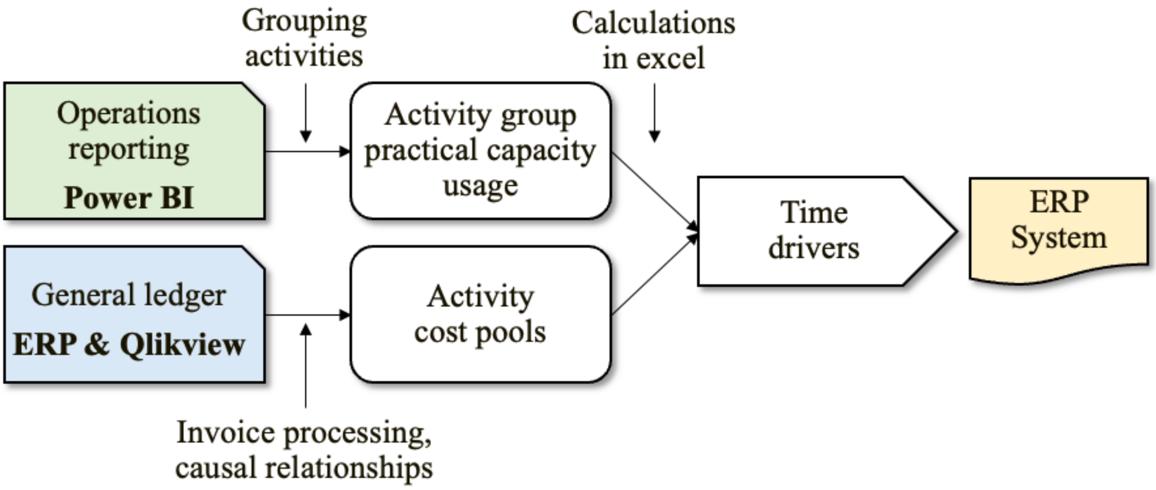

Figure 23: Calculating time drivers

The time drivers were determined in the following way: variable overhead costs for the activity group were divided by the practical capacity usage of the activity. A total of 22 different time drivers were calculated for the 14 activities (Figure 24). Values in the figure are for demonstrative purposes. Say the robot welding activity group is associated with 50 000 € of welding material procurements and the workstations of the group total 2000 hours of direct labor, the cost driver for robot welding is calculated as follows:

$$Cost\ driver = \frac{Cost\ of\ activity\ (€)}{Practical\ capacity\ usage\ (h)} = \frac{50\ 000\ €}{2\ 000\ h} = 25\ €/_{h} \quad (2)$$

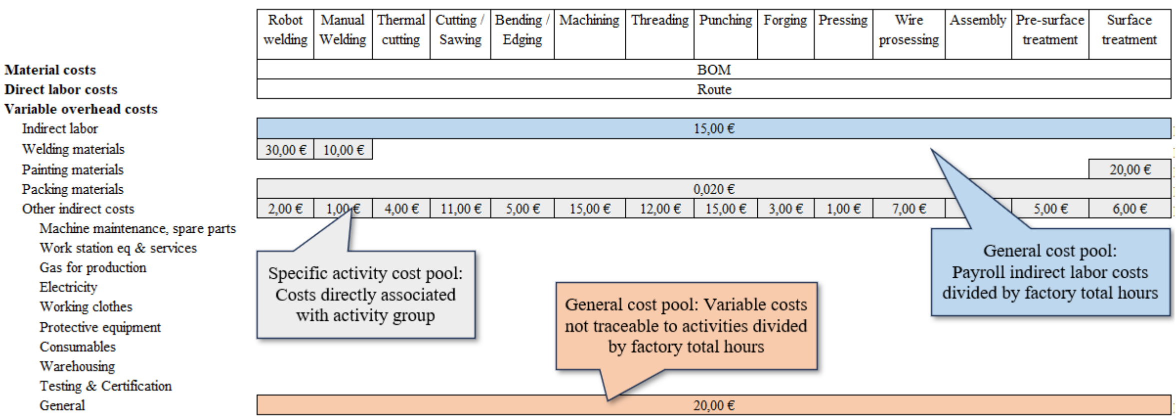

Figure 24: Calculating time drivers for activities

The calculated time drivers can be grouped into three categories. Firstly, indirect labor costs are allocated through a general time driver for all activities due to lack of visibility in the accumulated indirect labor costs in each specific activity. Secondly, welding, painting and other variable overheads are calculated by assessing the individual activities and their cost pools. Thirdly, some variable overheads can't be allocated to individual activities through estimations or invoice processing and are therefore allocated through a general time driver. An exception was made with production packing materials, which are calculated using the net weights of products as a cost driver. The goal is to reduce the amount of general cost pool allocations in both indirect labor and other variable overheads to properly depict the causal relationships between costs and activities. Improving the accuracy of allocations through reduced general rate usage will require more investigations as well as changes in costing procedures within the ERP system.

5.2 Basic structure of the revised costing system

After assessing the TD-ABC system objectives, assembling a costing development team, and determining the calculation principles for time drivers, the basic framework for the revised product costing system was be constructed. Figure 25 demonstrates the basic structure of product costing in the case company.

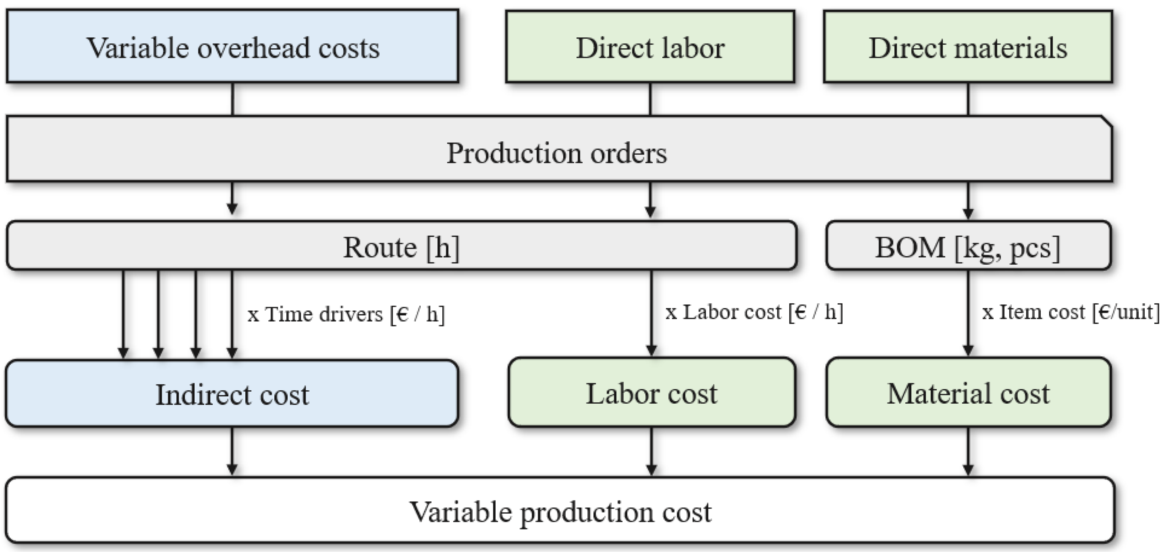

Figure 25: Case company product costing through TD-ABC

Direct production cost tracing remains the same with direct labor costs traced from production routing and direct material costs from product bill of materials. However, the variable overhead costs which were previously mere placeholder figures in reporting will be allocated directly to the stock value of goods through the ERP-integrated TD-ABC system. After launching the system, the COGS will contain cost types related to direct materials, direct labor, and variable overheads, thus improving the accuracy and reliability of sales margins.

5.3 Identifying the most influential constraints of system implementation

5.3.1 Physical process and ERP posting synchronization

Through practical experience, several challenges and constraints related to the implementation and use of a TD-ABC system were highlighted. The challenges can be categorized according to their impact on successful implementation as seen in figure 26.

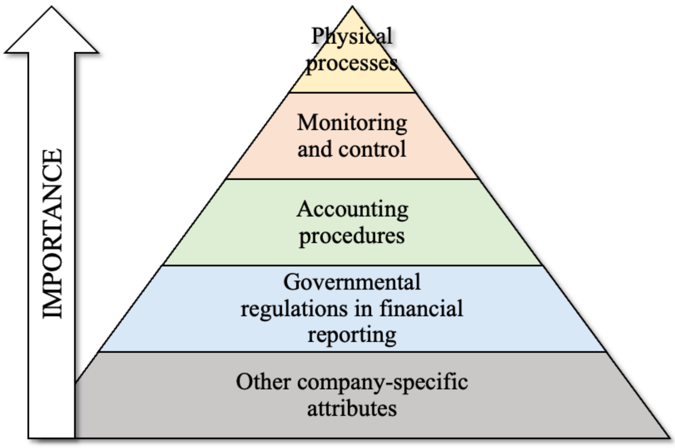

Figure 26: Main challenges of costing system implementation

Through assessments, five main challenges were identified. The most prominent challenge for successful implementation is the synchronization between physical processes and ERP system activities. To accurately conduct accurate and reliable product costing, the physical processes must match activities within the ERP system. As both the company's ERP system and product costing rely heavily on direct hour posting accuracy, this is the most critical success factor for implementation. Physical process matching to ERP processes was seen as one of the biggest risks, as the company's ERP system is still new to many units. Investigations assessing operations reports regarding the accuracy of planned and realized hours found a distinct correlation between the accuracy of direct hour posting and duration of ERP usage (Figure 27).

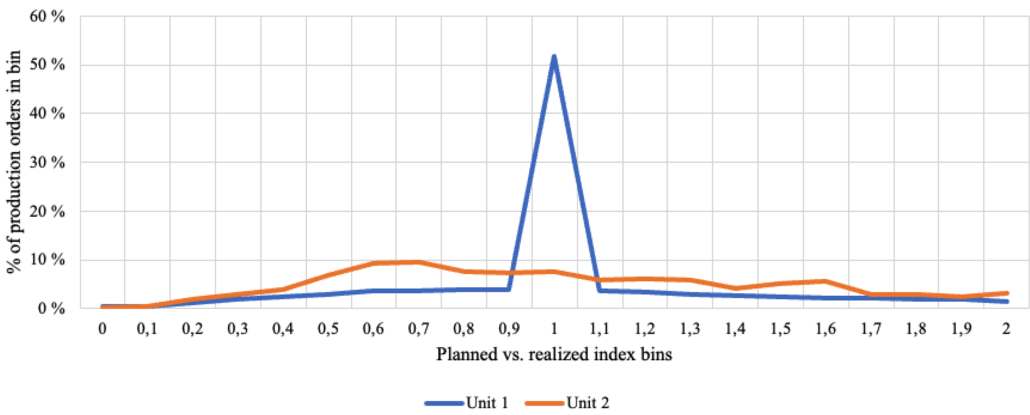

Figure 27: Realized hour accuracy comparison of units

In the reports, planned production hours are divided by realized production hours to create a posting hour index. Most postings should be closely situated on both sides of index value 1.0, where planned hours equal realized hours. Unit 1 was the first user of the new ERP with several years of system usage experience. The graph shows a great deal of production orders focused around the 1.0 mark in unit 1. Unit 2 however has been using the new ERP system for only three months and shows significantly more variance in production order posting accuracy. Additionally, in unit 2, a considerable amount of working hours were not posted to production orders at all and were thus inaccurately displayed as indirect working hours. In sum, reaching and maintaining accuracy in direct hour postings to the ERP system is the most paramount goal to achieve for reliable production costing through the TD-ABC system. If direct hours are wrong, the time drivers will also be distorted as the direct hours are used to estimate hourly cost rates for variable overheads. Further investigations concluded that manufacturing processes with lengthier production times are more likely to be recorded accurately. Therefore, manufacturing processes with low production times and high posting volume were deemed as the most volatile.

5.3.2 Monitoring and control

Uncertainty in the monitoring and control process of the new costing system was also seen as a key constraint for the development of a TD-ABC system. To depict product costs accurately, the allocation of overhead costs to stock value must be a dynamic and responsive process which considers the changes in production volumes and cost levels to reflect the true operating environment. The problem of monitoring and control is essentially an issue of reporting visibility when trying to compare the allocated overheads to actual expenses in financial statements. Figure 28 demonstrates the practical issue of reporting visibility briefly.

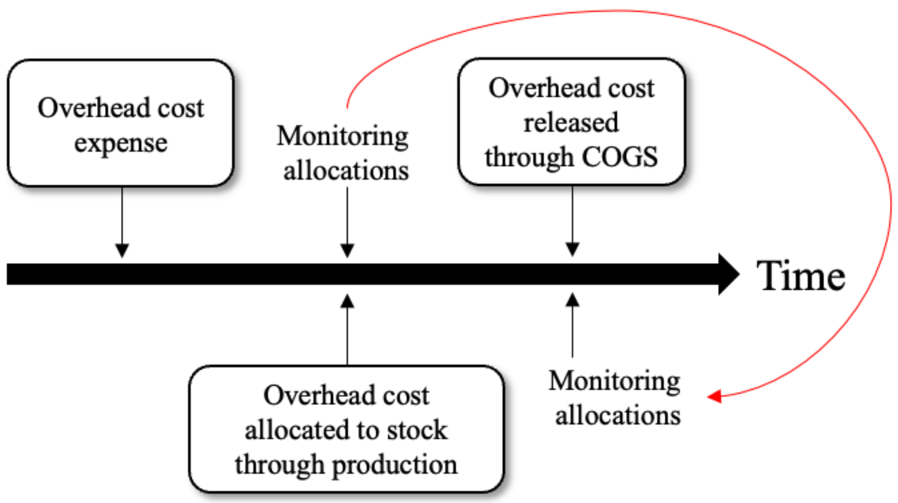

Figure 28: Cost allocation monitoring checkpoint

As variable overhead costs incur as expenses, they are gradually allocated to product stock value through the TD-ABC system. With the current reporting tools, the only way to monitor overhead allocation levels is through looking at the variable overhead general ledger accounts, inventories and allocation posting accounts. This view provides an overview of the general allocation level but doesn’t enable dynamic reactions.

Most items are manufactured to stock and not immediately sold to customers. Also, product throughput times are significantly long for most products. Therefore, the allocation to stock and subsequent release of overhead costs in profit and loss statements through the (COGS) creates a reconciliation issue between overhead costs expenses and allocation. An additional reporting tool must be developed to separate the direct and overhead costs included in the COGS. By creating transparency to the COGS, the allocation monitoring checkpoint can be moved to match the time of sales. This way the overhead costs released in the COGS can be compared to actual level of overhead costs during the same period. This monitoring view is rooted in the matching principle, which is a fundamental accounting guideline that dictates that expenses should be recorded in the period in which they are incurred and matched with the revenues of the period. By matching the costs and revenues of periods, the allocation rates can be dynamically adjusted to reflect the true operating environment of the company.

Overall, the control process must include a hands-on approach from both local controllers and group finance department, where allocations are systematically monitored and detailed explanations of any exceptions are made. For monitoring purposes, a dashboard view of allocation cost drivers, allocated sums and stock values as a whole and per unit should be created. In addition, local controllers should conduct monthly reporting of the TD-ABC system usage.

5.3.3 Accounting procedures

Another key factor for validating the causal relationships between costs and cost objects is the accuracy of accounting procedures related especially to variable overhead costs. The basis of cost allocation lies within obtaining sufficient information about the cost centers and financial resource data posted to invoices. Essentially, the TD-ABC time driver calculation logic needs to know which invoices are traced to which production resources to accurately determine the cost of manufacturing activities. Only around 50 % of cost invoices that could be directed to individual production workstations were in fact posted to them. These are invoices mainly related to machine spare parts, maintenance, equipment, and consumables. However, the issue is not only the level of invoice postings, but also concerns the lack of harmonization between general ledger financial resources and structures. Some units post variable overhead invoices directly to production resources, while other units use local general ledger accounts and resources for cost tracing. This creates difficulties in creating a uniform TD-ABC time driver template for all units. A mapping must be created to reconcile the various methods of invoice posting until a permanent solution to harmonize the processes can be put into place.

5.3.4 Governmental regulations in financial reporting

Governmental regulations also play a key role in the implementation of new product costing systems. In some units, the regulations enable various ways of overhead cost allocations, some units are situated in countries with extremely strict governance over stock valuation principles. The costing system must be developed in accordance with local governments to be successfully implemented.

Governmental regulations do not only require accuracy of the costing system, but also influence the way financial reporting, especially inventory change fields behave in profit and loss (income) statements. In Finland for example, inventory change fields only need to contain information about the cost of goods sold regarding finished and semi-finished goods, as well as direct labor, subcontracting, direct purchases, and adjustments of stocks. In other European countries however, the inventory change field must contain much more specific information, such as work-in-progress inventory, cost of trade goods sold, and changes in raw material, semi-finished and finished product stocks. Figure 29 illustrates the differences between the income statement inventory change fields of two units of the case company which operate in different countries.

	Inventory change
36000	Cost of goods sold, finished goods
36100	Cost of goods sold, semifinished goods
36130	Cost of Material & Semi-Finished -sold
36140	Cost of Trade Goods sold
36200	Adj. of stocks of finished
36205	Adjustment of material stock
36210	Adjustment of semi-finished stock
36230	Adjustment of trade goods stock
36232	Semi-finished manufactured cost
36233	Finished goods manufactured cost
36240	Change in raw material stock
36241	Change in semi-finished stock
36242	Change in finished products stock
36243	Consumption of Material - WIP manufacturing
36244	Consumption of Semi-Finished - WIP manufacturing
36246	Change of WIP
36250	Direct labour - contra account
36251	Direct labour -contra account 2
36275	Allowance of inventory
44000	Direct purchases - contra account

	Inventory change
36000	Cost of goods sold, finished goods
36100	Cost of goods sold, semifinished goods
36200	Adj. of stocks of finished
36201	Adjustment of stocks, manual
36250	Direct labour - contra account
36260	Subcontracting -contra account
44000	Direct purchases - contra account

Figure 29: Differences in inventory change fields in the income statement between two units of the company

As the TD-ABC system is implemented directly to the ERP system and uses general ledger accounts to allocate overhead costs directly to financial stock value through production postings, careful attention must be paid when creating the posting structure for balance sheet and profit and loss statements. All units have different profit and loss statement and balance sheet structures due to local regulations, so every unit must be reviewed separately when setting up the general ledger posting rules and financial statement structures for the TD-ABC system.

5.3.5 Other company-specific attributes

Besides governmental regulations in financial reporting, there are other company-specific attributes to consider in the development of the TD-ABC system. These are issues related to the differences in production setup parameters in units' ERP systems. The TD-ABC costing system utilizes data from the production costing and production routing parameters and requires an exact structure of cost categories for production routes and resources to operate correctly. Some units have been found to have inadequate costing setups which are time-consuming to correct since there are thousands of production routes with faulty costing setups. Before implementation, these issues must be corrected.

5.4 Overcoming key constraints of implementation

5.4.1 Standardized procedures among units

Considering the previously mentioned issues, this chapter focuses on the specific actions and plans needed to successfully overcome any limitations of system implementation. Firstly, work to accurately synchronize physical manufacturing processes with ERP activities has been started in cooperation with operations executives from group departments as well as departments of each unit. Extensive studies to planned and realized hours, production posting procedures and factory workflow have been conducted and discusses together with stakeholders in recurring meetings. Special focus was taken to consider the manufacturing processes with low production times and high posting counts. Overall, the raised attention to the importance of direct hour correctness has shifted the mentality of executives and factory workers alike to work cooperatively to improve ERP data reliability.

Accounting procedures, governmental regulations, and other company-specific attributes have been considered when developing the TD-ABC system structures and time driver calculations. Firstly, accounting procedures have been studied in the units together with local financial executives. Any deviations from standards have been documented and change management actions have been taken. For example, mandatory further identification information fields were added cost invoices for spare parts and consumables to improve allocation accuracy. In addition, mappings of accounting identifications were constructed to utilize similar time driver calculation formulas among units.

The process to fully unify accounting procedures is lengthy and unlikely, but with the collected findings it is possible to modify the TD-ABC system structure according to each unit's specific needs. However, the focus is to keep the costing structure and time driver principles as similar as possible among units to maintain comparability of figures. Governmental regulations mostly affect the general ledger accounts and financial report structures. Additional general ledger accounts and unit-specific posting rules have been created and adapted to use to satisfy local legislation. Lastly, other company-specific attributes such as different production routing and costing parameters have been reconciled in cooperation with local executives to satisfy the needs of the TD-ABC structure.

5.4.2 Gaining transparency to the cost of goods sold

Modification work for internal reports was started several weeks before the implementation of the TD-ABC system. The modification work includes changes in internal sales reports as well as developing new reporting tools to gain transparency to the COGS. Additional allocation methods for reporting purposes to include non-inventoriable costs in sales reports were also developed internally with the IT and reporting team. The reporting modifications are not finalized at the time of writing this thesis, but demonstrative images are used to explain the modifications. Firstly, the current placeholder figures for variable overhead costs need to be removed from internal sales reporting as in the future, variable overhead costs will be displayed directly in the total production cost of items. Table 6 demonstrates the current layout of internal sales reporting.

Table 6: Example of case company internal sales report

Product segment	Product	Quantity	Turnover	Direct cost	Variable overhead cost	Sales margin	Sales margin (%)
Segment 1	Product X	2 492	361 365 €	257 999 €	44 274 €	59 091 €	16 %
	Product Y	1 022	136 141 €	93 943 €	31 966 €	10 232 €	8 %
	Product Z	881	1 271 671 €	659 750 €	260 619 €	351 301 €	28 %
Segment 2		4 929	714 754 €	341 087 €	46 959 €	326 709 €	46 %
Segment 3		59 993	7 991 668 €	3 783 572 €	1 795 230 €	2 412 866 €	30 %
Segment 4		28 391	1 233 305 €	479 185 €	223 178 €	530 942 €	43 %
Segment 5		21 012	3 046 950 €	1 993 013 €	690 270 €	363 667 €	12 %
Segment 6		8 457	1 126 557 €	714 868 €	277 291 €	134 398 €	12 %
Segment 7		2 782	4 015 650 €	1 677 197 €	393 211 €	1 945 242 €	48 %
Segment 8		2 222	322 212 €	148 113 €	57 331 €	116 768 €	36 %
Segment 9		2 984	397 499 €	178 568 €	69 378 €	149 553 €	38 %

All the data within the sales report example is purely fictional as the purpose is to create an understanding of the current nature of product sales margins. In the report, the direct cost and variable overhead costs are deducted from the turnover to produce sales margins. The sales margin percentage is calculated by dividing the sales margin by the turnover. Currently, the highlighted variable overhead cost fields only contain placeholder figures instead of true values of overhead allocated to stock as demonstrated in figure 19. After implementing the TD-ABC system, the variable overhead costs in the sales report will directly utilize the same information as direct costs. In practice this means fetching data from production order costing tables and grouping them by three cost types: material, labor, and variable overhead costs.

Splitting the COGS into components is a task which requires huge efforts from a data processing and reporting point of view. The case company has a significant amount of Make-to-Storage (MTS) manufacturing, which means that many end products use the same components. In practice, it equates to not having direct links between end-product and sub-product production orders. Therefore, when assessing the costs of items, the production cost split to materials and labor are visible only for the last step of production. All sub-order costs are accrued to the material cost type, rendering the current cost split data largely unusable. In the COGS-splitting report, production transactions and settlements need to be analyzed iteratively to uncover the realized costs of the whole manufacturing chain (Figure 30).

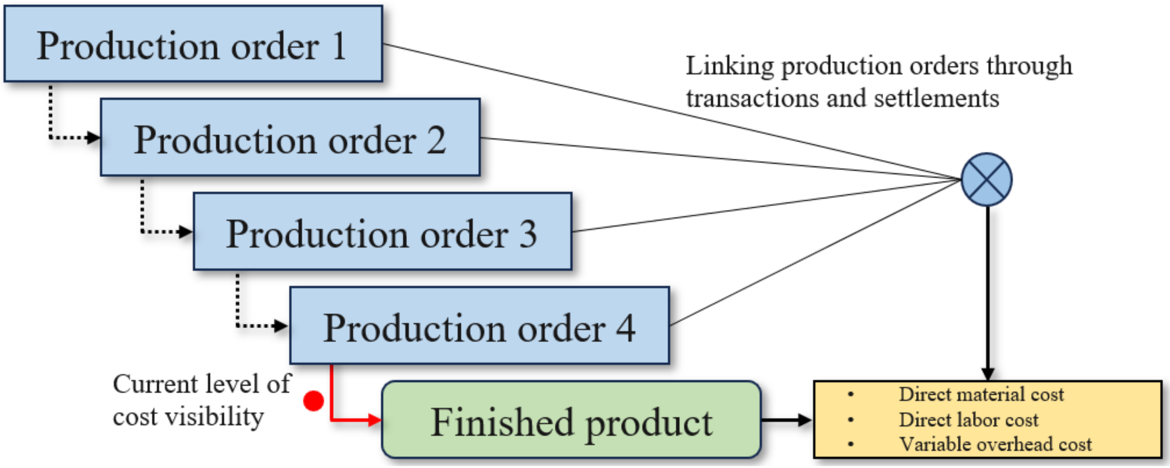

Figure 30: Developed approach to assess costs of the entire manufacturing chain

Development of the COGS-splitting reporting tool with BI reporting consultants has started and is showing promising signs. In the report, various cost types throughout the whole production chain can be analyzed for each item with additional filtering for companies, segments, customers, product families. Overall, the developed tool is functional, but still needs to be integrated to the existing internal sales report. Table 7 demonstrates the outlook of the sales report after implementing the new costing system and reporting tools. Again, the information in the example is purely fictional, only meant to display the impact of changes in costing and reporting visibility.

Table 7: Proposed structure for internal sales reports

				Cost of goods sold			Allocation tool		
Product segment	**Product**	**Quantity**	**Turnover**	**Direct materials**	**Direct labor**	**Variable overhead**	**Customer-related**	**Sales margin**	**Sales margin (%)**
Segment 1	Product X	2 492	361 365 €	206 400 €	51 600 €	44 274 €	10 320 €	48 771 €	16 %
	Product Y	1 022	136 141 €	75 154 €	18 789 €	31 966 €	3 758 €	6 475 €	8 %
	Product Z	881	1 271 671 €	527 800 €	131 950 €	260 619 €	26 390 €	324 911 €	28 %
Segment 2		4 929	714 754 €	272 869 €	68 217 €	46 959 €	13 643 €	313 065 €	46 %
Segment 3		59 993	7 991 668 €	3 026 857 €	756 714 €	1 795 230 €	151 343 €	2 261 523 €	30 %
Segment 4		28 391	1 233 305 €	383 348 €	95 837 €	223 178 €	19 167 €	511 774 €	43 %
Segment 5		21 012	3 046 950 €	1 594 410 €	398 603 €	690 270 €	79 721 €	283 946 €	12 %
Segment 6		8 457	1 126 557 €	571 894 €	142 974 €	277 291 €	28 595 €	105 803 €	12 %
Segment 7		2 782	4 015 650 €	1 341 758 €	335 439 €	393 211 €	67 088 €	1 878 154 €	48 %
Segment 8		2 222	322 212 €	118 491 €	29 623 €	57 331 €	5 925 €	110 844 €	36 %
Segment 9		2 984	397 499 €	142 854 €	35 714 €	69 378 €	7 143 €	142 410 €	38 %

In the revised sales report, splitting the COGS into three different columns allows for more transparency of the sales margin. Not only does the split allow for transparency to sales margins and accurate monitoring of variable overhead allocations according to the matching principle, but also provides valuable information about the direct costs of manufacturing. Management can now more efficiently investigate fluctuations in sales margins by assessing the portions of direct labor and direct materials as well as variable overhead costs. For example, by looking at the development of a certain product family's costs, it's easy to identify whether changes in costs are caused by material cost fluctuations or changes in direct labor efficiency. In sum, the three-component COGS figures will make it easier to evaluate costs and level of profitability on product, family, segment, business, or total level to accurately assess the reasons behind cost changes in different periods.

Modifying the existing principles and methods of presenting variable overhead costs in sales reports reporting is not the only necessary change to be made. Accounting legislation dictates that only costs associated with manufacturing activities can be included in stock value, thus imposing a limitation to what overheads can be allocated through the TD-ABC system. Hence, the allocation must exclude all costs directly related to manufacturing, most importantly, customer-related costs. Customer-related costs incur due to transport costs, order processing and use of packing materials in shipped end-products. These are important non-stock-valued costs to consider in sales reports, therefore a new field for customer-related costs must be added. The tool will utilize rough estimates for customer-related costs per product family. The value will only be visible in reporting, not in the actual stock value.

5.4.3 Plan for managing technical tasks and stakeholders

When evaluating the goals and challenges related to implementing and utilizing the TD-ABC system, while also considering the complexity of processes and scope of overhead costs, a recommended process model for implementation can be developed. Figure 31 showcases the TD-ABC system implementation process milestones and tasks. Keeping in mind the complex nature of implementing new technologies in large companies, technical and stakeholder streams have been separated to satisfy both technical and managerial needs. The stakeholder stream consists of tasks related to organizing, informing, and educating costing system stakeholders and thus aligning personnel towards a common goal while mitigating change resistance. Conversely, the technical stream entails tasks required to prepare, operate, and monitor the TD-ABC system.

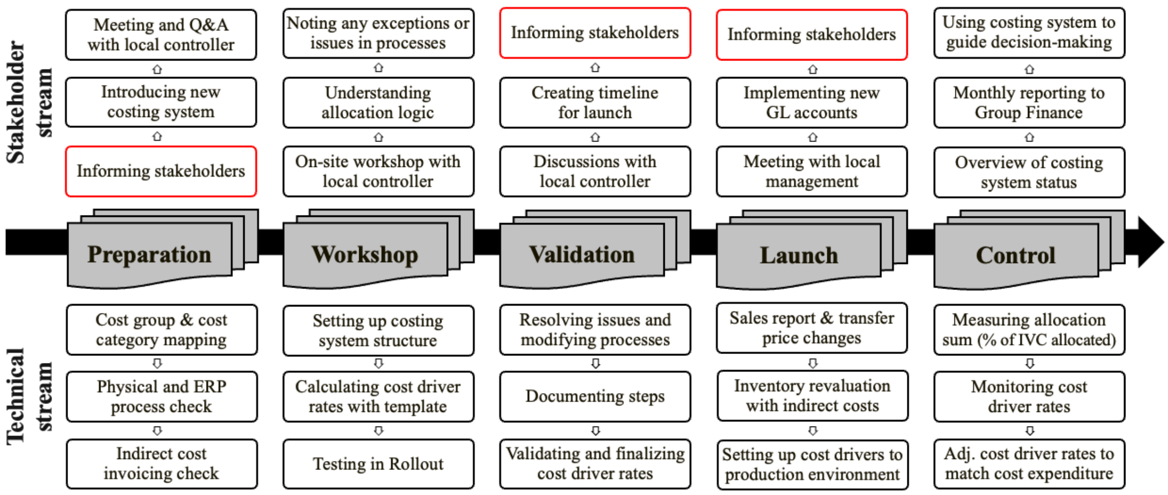

Figure 31: TD-ABC system implementation model in case company

In the preparation phase, stakeholders are informed, and basic principles of the costing system are discussed with unit controllers. ERP system cost structures are then discussed and defined in co-operation with units. Physical process to ERP process matching is conducted and the overhead cost scope and costing procedures are also reviewed. In the workshop phase, live meetings are set with unit controllers and deeper understanding to the costing system is gained. Any exceptions in manufacturing processes or costing procedures are documented. Then, the costing system structure is set up and preliminary cost driver rates can be calculated and tested in the ERP sandbox environment. After the workshop, the validation phase begins. Any remaining issues in physical and virtual processes are to be fixed and documented in co-operation with unit controllers and management. Final cost driver rates can now be calculated, and a detailed launch timeline can be produced and informed to stakeholders. Before official costing system launch, a final checkup with unit management is conducted and reporting changes in both managerial and financial reports are finalized. After inventory closing, inventories are revalued through closing adjustments to include variable overheads to existing stock. Finalized cost drivers and costing structure is implemented to the main production environment in the ERP system. The five-stage process will be repeated monthly for each unit as they will be added to the costing system domain to manage organizational capacity.

5.4.4 Effective costing system monitoring and control

The main task of monitoring and controlling the system is to ensure the accuracy of variable overhead costs allocated to stock. Firstly, time drivers are calculated by each unit's business controller according to mutually agreed calculation principles and provided calculation examples. The time drivers will be recalculated monthly or quarterly with a rolling 12 month focus to reflect the true operating environment, with a possibility to adjust cost allocation pools if needed. For example, if last year's electricity agreement was significantly higher than this year's, it's possible to adjust the time drivers to reflect the upcoming electricity costs. Local controllers have a responsibility to document any adjustments and assess overall accuracy of allocations by closely monitoring product cost and sales margin development in their respective units. The development team will oversee the cost allocation status through a dashboard view similar as what is demonstrated in figure 32. The monitoring system will be developed with time as the key monitoring points are better clarified.

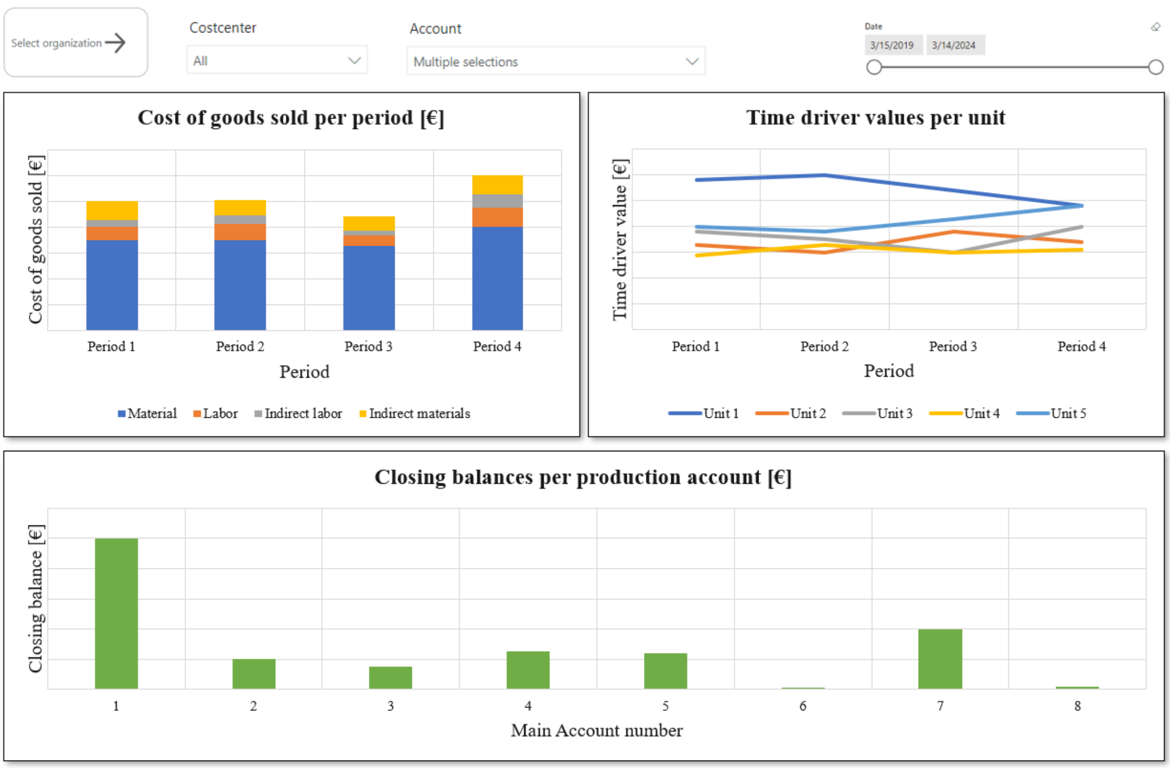

Figure 32: Dashboard view for TD-ABC system monitoring

The costing development team will initially monitor cost allocations to stock from three different perspectives: by comparing the cost driver values in different periods and different companies, by assessing variable overhead general ledger entries and balances, and by comparing the allocated sums to variable overheads released as expenses through the COGS. The dashboard view is connected to production environment data through an SQL connection. All the required data is readily available but requires additional reporting logic to be combined and displayed correctly. Development work for the dashboard reporting view from these perspectives is under construction with BI consultants, and changes to the structure and level of detail are still possible. The developed reporting will enable a snapshot overview of the status of each unit's allocation rates, allocated and expensed overheads, as well as their development over periods. When exceptions occur, actions will be taken to correct any deviations in cooperation with local units.

6 Results and discussion

6.1 TD-ABC system development framework

After assessing management accounting core concepts and scientific articles related to the research, an understanding of successfully developing and implementing costing systems in manufacturing settings could be achieved. The empirical findings and practical experience from the development process were combined with theoretical knowledge to construct a similar development process framework as discussed in chapter 3.5 (Figure 33). The constructed framework summarizes the results of this research similarly to previously presented development models in figure 10, figure 12 and figure 13. From the Design Science Research perspective, the framework is one of two key construction artifacts and main deliverables of the thesis.

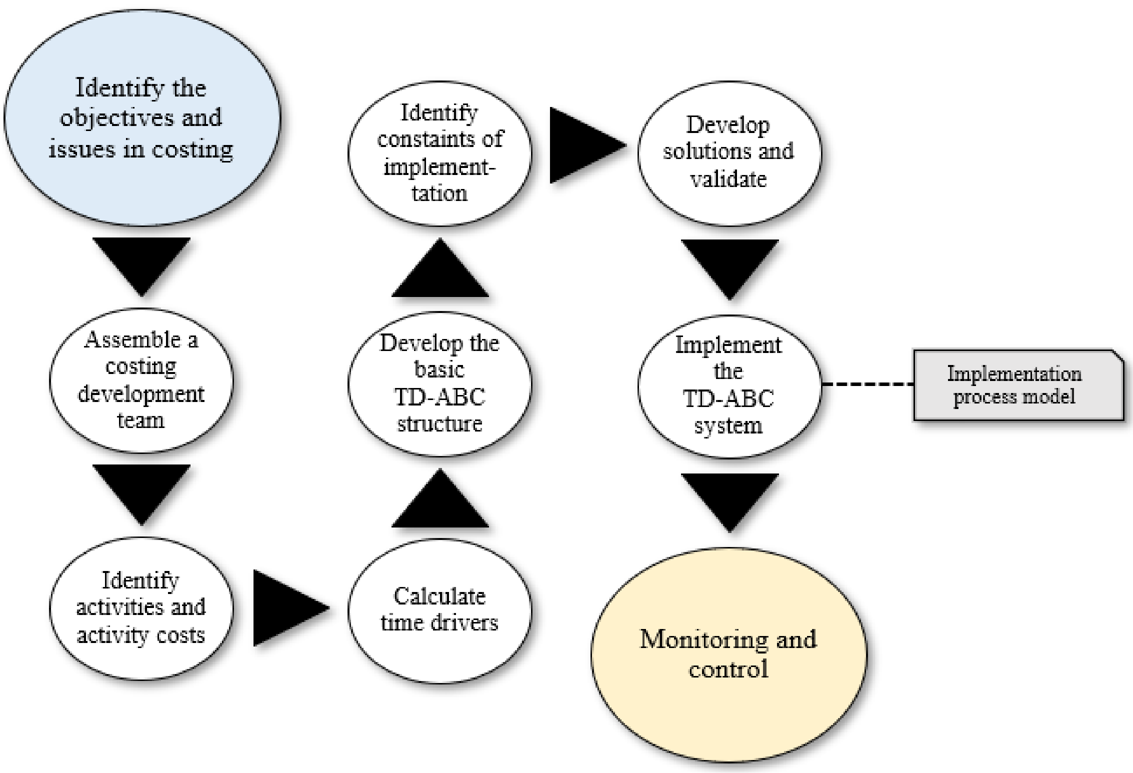

Figure 33: TD-ABC system development framework in the case company

Firstly, objectives and issues in current costing systems and procedures are identified. A costing team is assembled to establish leadership and control for the development project as well as to mitigate change resistance. The costing development team works to identify various manufacturing activities, cost levels and causal relationships between costs and activities. After validating the relationships, the team forms the basis of time driver calculations which will be used in the TD-ABC system. The time drivers will largely dictate the structure of the costing system built into the ERP system. The costing development team actively engages with stakeholders and consultants to identify possible challenges and constraints of implementing the system while documenting all key elements. The documentation will be further utilized to develop functional and long-lasting solutions to successfully implement and use the developed system. An implementation process model will be constructed to guide the technical and stakeholder management tasks related to concrete tasks within the implementation. Following the implementation process model, the system is adopted to a pilot unit and results are carefully monitored through active co-operation between the costing development team and local controllers. Many of the greatest challenges in developing and successfully implementing the TD-ABC system are tackled during the first pilot unit implementation process, making the subsequent implementations in other units more straight-forward.

6.2 Examining the developed TD-ABC system

6.2.1 Overview of development and implementation in pilot unit

In March 2024, the developed TD-ABC system was adopted in a pilot unit. The process from the first decision to develop the system until launch lasted over a year. However, many of the initial tasks required for implementation were related to overcoming organizational challenges and meeting goals of the company’s product costing altogether. The actual implementation process for the specific pilot unit started in August 2023 and ended in a successful launch in the beginning of March 2024 after 6 months of work. Further unit implementations are expected to be delivered during the proposed 3-month implementation process period (Figure 31).

Overall, the practical development and application of the system closely followed the constructed development framework (Figure 33) as well as the implementation process model (Figure 31). To summarize, work in the pilot unit started by introducing the costing system to local controllers and assessing the status of costs and activities. In the upcoming weeks, a workshop was conducted where the focus was to gain a mutual understanding of how the TD-ABC system functions while documenting any issues or exceptions in existing procedures. The costing system structure was created in an ERP testing environment, preliminary time drivers were calculated together with controllers and the system was tested in detail. Next, during the validation phase, any issues were resolved, and correctness of allocations was ensured. A schedule for launching the system was created in coordination with the costing development team and the local unit. Stakeholders were informed of the decision. During the launch phase, modifications in managerial reports and financial statements were conducted, and the time driver rates were finalized. Previously existing inventories were revalued to include calculated variable overhead costs to mitigate a slow rise in inventories. On the day of launch, the final TD-ABC system structure was set to the production environment along with finalized cost drivers. Existing production orders were then re-estimated to include the newly added cost elements.

6.2.2 TD-ABC system construction

After successful development, developed TD-ABC system was directly integrated to the company's ERP system (Figure 34). Figure 20, figure 23, and figure 25 were combined to showcase the final construction of the TD-ABC system. This is an additional key construction artifact of the adopted Design Science Research.

The model is intended to be used for full variable costing purposes, where both direct production costs and variable manufacturing overhead costs are included to stock value solely through production order postings. When the produced goods are sold, the manufacturing costs are released as expenses through the COGS. Direct production costs are traced directly through BOM and route structures, while variable overhead costs are causally linked to manufacturing activities and combined to production orders through activity-specific time drivers. Data from general ledger accounts, invoice processing, operative data were combined in an excel file to calculate the time drivers.

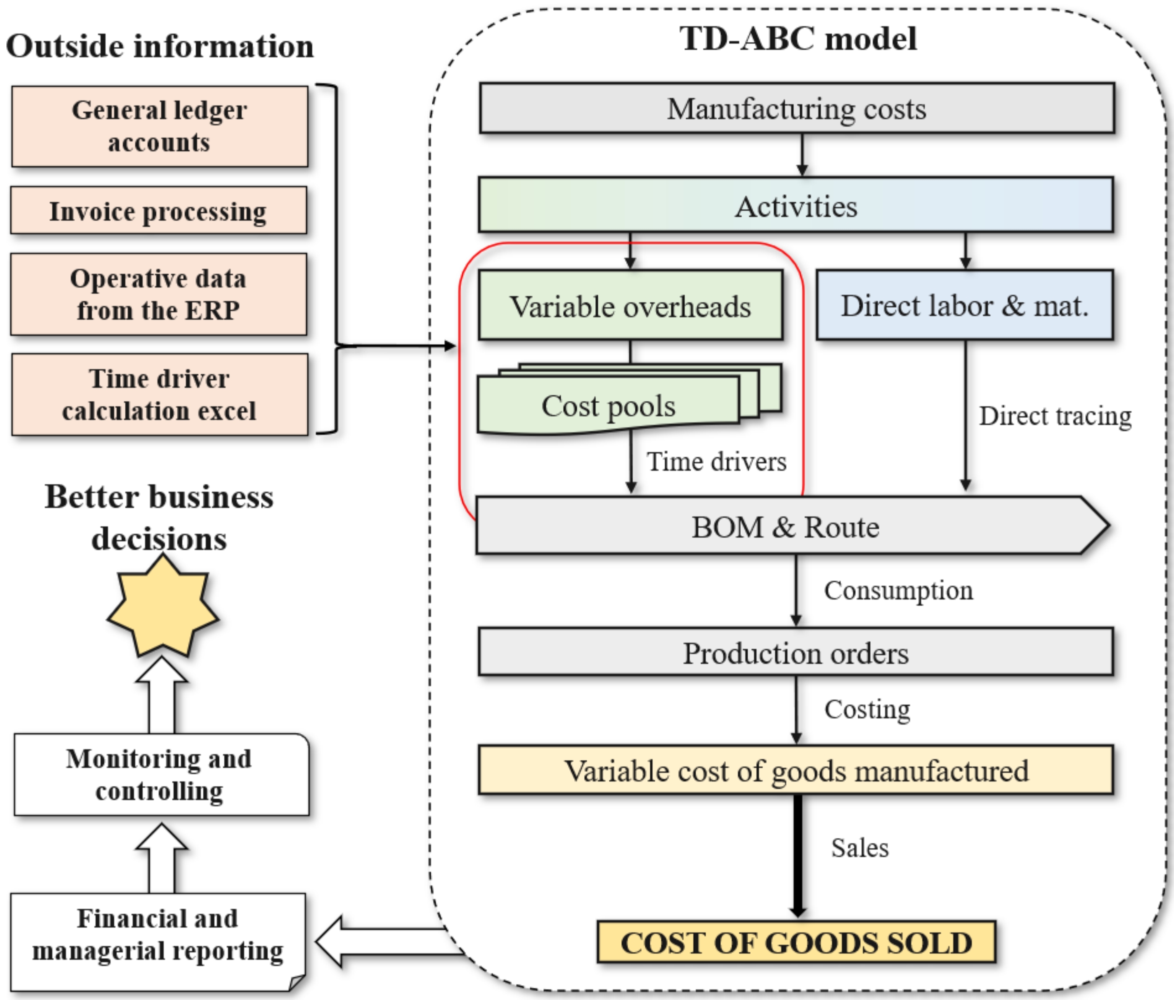

Figure 34: Comprehensive structure of the developed costing system

Costs allocated by the TD-ABC system are visible in financial and managerial reports. Manufacturing costs and COGS figures can be viewed from financial profit and loss statements, as well as operative production cost reports, sales reports, and inventory reports. Overall, the financial and managerial reports are used to monitor and control the system primarily through assessing general ledger allocation account balances, time driver values and variable overhead costs released as expenses through COGS. Through systematic and iterative monitoring, the time drivers are adjusted monthly or quarterly to maintain a correct allocation level as operating rates and costs fluctuate.

Figure 35 simplifies the developed TD-ABC structure within the ERP system. The construction is straight-forward: Cost of goods manufactured is a resulting total cost line of direct manufacturing costs and variable overhead costs. The linking of variable overhead costs to activities is conducted through the usage of cost category and cost group parameters within the production resource and production route settings.

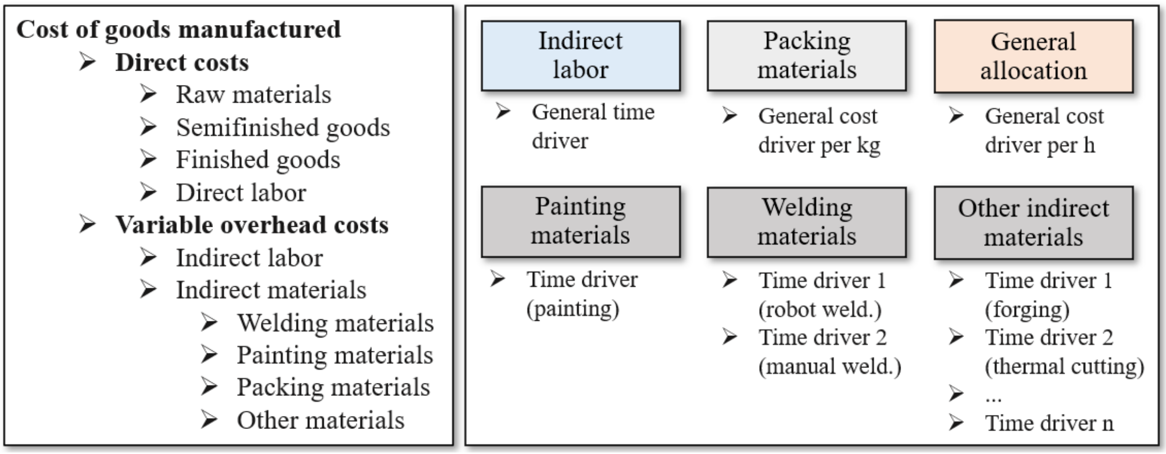

Figure 35: TD-ABC system structure in pilot unit

Variable overhead costs are directed to certain activity groups by utilizing separate time drivers. Indirect labor costs are allocated to products using a single time driver. Indirect materials are further grouped to welding, painting, packing and other materials. Indirect welding materials have two separate time drivers for robot welding and manual welding. Painting materials have a time driver only linked to painting activities. Packing materials utilize a general allocation rate per consumed kilogram of materials. Other indirect materials such as spare parts, consumables and maintenance have 14 unique time drivers for each different activity calculated based on invoices directed to workstations. Remaining indirect materials that can’t be allocated directly through activities are handles through a general allocation time driver.

6.2.3 Practical example of product costing

As the TD-ABC system was taken to use in the pilot unit, production costing began including direct and indirect cost elements. Figure 36 showcases the manufacturing and costing process of a simple standard product. All values used are purely fictional and serve the purpose of demonstrating how the end-product cost if formed.

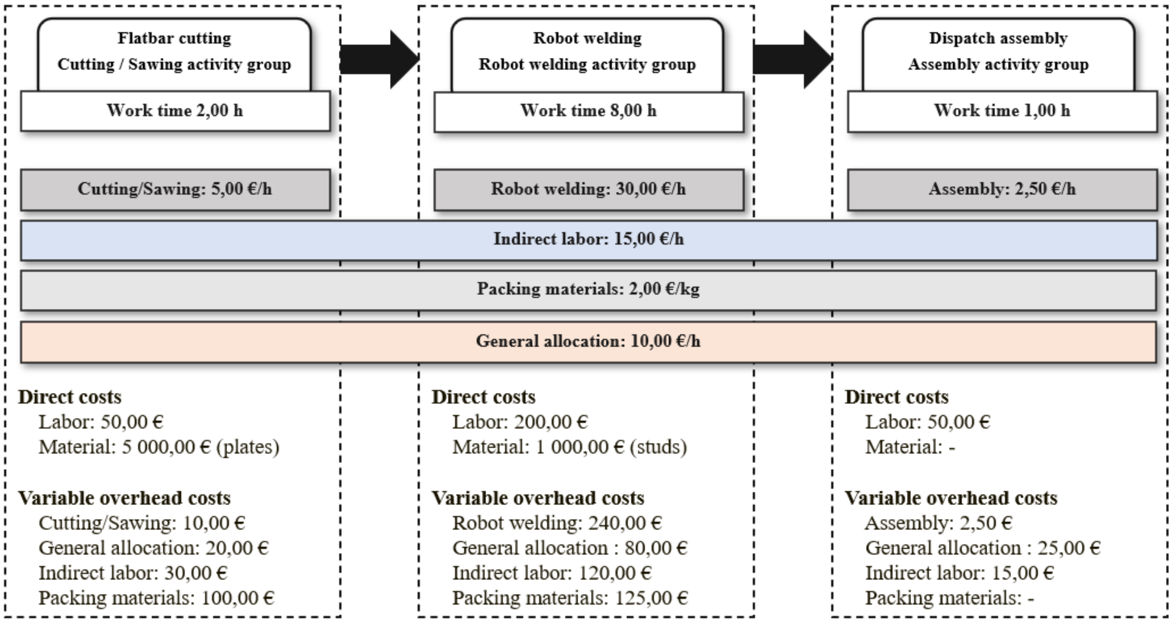

Figure 36: TD-ABC product costing example in pilot unit

The production process includes three stages: flatbar cutting, robot welding and dispatch assembly. Costs from each production stage are accrued to semi-finished and finished products through direct labor, direct materials, and variable overhead allocations. Ultimately, the COGS of each item will be a s6m of these costs. In total, the finished product has a resulting manufacturing cost of 7 067,50 €. The manufacturing cost can be further split into 6 000 € of direct materials, 300 € of direct labor and 767,50 € of variable overhead costs. Every product manufactured in the pilot unit utilizes the TD-ABC system, and subsequently displays costs in a similar manner. Therefore, the COGS of sold items also include the variable overhead costs from production postings.

6.2.4 Stakeholder feedback and findings

After the pilot unit implementation process, valuable information was acquired through the practical work and through communicating with stakeholders. Business controllers and operations executives from both the local units and parent company expressed their satisfaction with the current system and how the implementation went altogether. Perhaps the most important feedback and findings were related to the used TD-ABC principles themselves. Using time as a main driver of costs seemed to effectively align the interests of financial and operative departments, which raised the interest of both parties while starting serious discussion about the impact of the new approach. From a financial viewpoint, in manufacturing, variable costs are caused by fluctuations in the operating rate. From an operative viewpoint, fluctuations in the operating rate are clearly visible in the production working hours. Thus, a common measure of cost-causation was found for financial and operational departments. This sparked several development initiatives to assessing the current cost estimation methods, examining production posting principles on the factory floor as well as analyzing the accuracy of direct hours across several units. Here, a common understanding of costs was formed between the parties to foster an increasingly symbiotic relationship between the two departments.

Employees working in the parent company finance department highlighted the importance of having created a detailed framework for the development process, where individual tasks and responsible employees were carefully listed. The plan was sufficiently accurate and made stakeholder engagement and progress tracking simpler. Timely completion of the pilot implementation was also seen positively, as it indicates that the remaining units can also take the new system to use according to the given schedule.

Another positive note was that many manufacturing units of the company will also benefit from the developed TD-ABC system through more effective and automated inventory costing. In several units, including the pilot unit, governmental regulations require monitoring and allocation of variable overhead costs in financial inventories. The process of allocating variable overhead costs to inventories is currently conducted manually through an extensive and time-consuming process, which is altogether unhelpful in decision-making due to the lack of product-level allocations.

Financial closing of March 2024 indicated that the time drivers produced satisfactory first results and the TD-ABC system was working as expected but required fine-tuning. Stock allocations through the TD-ABC system were in line with the period costs for variable overheads in the past months and the general ledger entries were functioning as planned. The controller report also indicated improvements in the reconciliation of sales margins in both managerial and financial reporting. However, establishing a systematic monitoring and control process of the TD-ABC system will require several months of experience, as well as system usage in more units for effective comparisons of allocations.

Some issues with the implementation were discovered by local controllers and the development team. In rare cases, the stock prices of goods were not revalued in the inventory closing adjustment due to the product being a physical good instead of a financial good. Inventory closing only affects financially valued goods, therefore production order goods not yet costed were not included in the revaluation. In other cases, the inventory adjustment effectively changed the historical inventory value of items within the ERP due to the system's weighted average inventory calculation logic. Additionally, a small number of items experienced errors with production routing, leading to missing time drivers in their production orders. One general ledger account required by the TD-ABC system was left as suspended during launch, causing initial errors in production postings. The account was however quickly opened on the day of launch, creating only a small window of failed production postings. All in all, despite the detected flaws, the implementation process went according to plan. The system is stable, and stakeholders are satisfied with the end-result and the system can be implemented into further units as planned. However, in terms of full-scale monitoring and results, more system usage time is needed. Also, as more units start using the TD-ABC system, comparing and benchmarking results will serve as an important indicator for allocation accuracy and system function.

6.3 Further development of the system

6.3.1 Assessing the possibilities of allocating fixed overhead costs

In general, the TD-ABC approach is a functional and accurate method for allocating variable overhead costs to products. However, variable overhead costs only accounted for 18 % of manufacturing costs whereas fixed overhead costs held a share of 20 % of total manufacturing costs. As discussed in the theoretical research part, using time drivers for fixed overhead cost allocation might not result in accurate or reliable product costs, questioning the usefulness of a TD-ABC approach. However, the developed product costing system is capable of technically supporting fixed overhead cost allocations in more ways than through time drivers. Technical features are not the main constraint of fixed overhead cost allocations. Rather, switching from variable costing to full absorption costing is likely too big of a change for the organization during the proposed timeline.

As described in chapter 3.6, variable overhead costing is a common approach to guide decision-making in sales and operations due to its way of displaying incremental costs for products while dynamically responding to changes in operating rates. With a full absorption costing approach, costs previously considered as period costs are included to inventories and are present in the unit costs of items and therefore changes in operating rates will affect product cost figures significantly.

Table 8 showcases the cost elements of the case company on an overview level. The current direct costing procedures alongside the developed TD-ABC system for allocating variable overheads consider the first half of listed costs. Customer-related costs and non-manufacturing related fixed costs are not considered in the product or inventory costing approach, but rather displayed only for reporting purposes if needed. The remaining fixed overhead costs from projects, operations and depreciations for machinery are thus the allocation focus. The impact of these costs is significant, and therefore they require rightful methods of allocation to ensure product cost correctness.

Table 8: Case company cost types and costing methods

Requirement	Description	Cost element	Cost type	Costing method
IFRS	Inv. Value	Material costs	Direct	Direct
	BOM+Route	Subcontr. Costs		
	Route	Direct labor		
IFRS	Allocation to items	Indirect labor costs	Variable	TD-ABC
		Indirect variable costs		
		Paints, chemicals		
		Welding materials		
		Electricity, heat, fuels		
		Spare parts, consumables		
		Repair, maintenance		
NOT	Allocated to customers	Dispatching labor costs	Fixed	Reporting
		Packing materials		
		Sales freight costs		
IFRS	Fixed project costs	Internal work costs (project-related)	Fixed	?
		Outsourced costs (project-related)		
IFRS	Fixed costs	Operations	Fixed	?
NOT	Fixed costs	Sales & Marketing	Fixed	NOT
		Administrative		
		Research & Development		
IFRS	Depreciation	Operations machinery	Fixed	?
		Other	Fixed	NOT

From the case company’s perspective, including fixed costs to inventory values will reduce the amount of expenses during any given period by including them to inventory costs. This will ultimately result in a loss of visibility for sales margins in both financial statements and managerial reports as production operating rates fluctuate even slightly. Let’s look at a situation where the case company is using full absorption costing, and only producing items to stock with very little sales. In this situation, inventory balance increases significantly, because manufacturing costs, including fixed costs are capitalized into the inventory. Positive cash flow to the inventory coupled with a very small impact from cost of goods sold inevitably leads to a situation where the sales margin is severely inflated.

Conversely, when selling stock with little production, the positive cash flow to inventory is small, while the expenses released through COGS is very high, resulting in very low sales margins. Overall, the full absorption costing method brings stability to the EBIT (Earnings Before Interest and Taxes), as the impact of operating rate fluctuations is displayed in the sales margins rather than in earnings. In a variable costing approach, fluctuations in the operating rate are not displayed in sales margins, but rather in the EBIT. Both options are useful in certain scenarios, but from an internal business management viewpoint, variable costing margins are more useful to assess the current situation and internal efficiency of the organization.

Keeping reliable sales margins which are useful and informative for the organization’s executives is a paramount goal to consider. This significantly affects the decision of switching from variable costing to full absorption costing. When assessing the proposed requirements and needs as well as the scopes of costs, there are two viable recommendations for introducing fixed costs to inventories to meet IFRS IAS 2 requirements:

1. Creating a new level of sales margin tracking in which fixed costs are included in the unit cost of products but not displayed in managerial reports.
2. Tracking sales margins on variable cost level and independently allocating fixed overheads to the balance sheet.

In the first recommendation, the organization will be introduced to a new level of sales margins, which are compliant with full absorption costing methods. The existing product costing system can be modified to allocate fixed manufacturing overheads directly to stock value of products through production postings, akin to the currently developed process.

Fixed overheads can be allocated to semifinished or finished products or both in several ways: per weight, per quantity or through a surcharge. The allocation can be further directed to business, product segment, or product family levels. Therefore, product level costing will account for all manufacturing costs, including fixed overheads. To keep accuracy for variable costing margins from the sales department's point of view, sales reports can be modified by adding tools and logic to remove allocated fixed overhead costs from product-level costs. However, financial reports cannot be modified so easily this way, inducing a risk of sales margin-level visibility loss in profit and loss statements. Financial sales margins are actively monitored by finance and management executives to measure the operative profitability of the organization. Reducing the reliability and transparency of this key performance indicator will significantly change the current way of analyzing business profitability figures from a sales margin viewpoint. However, with a full absorption costing view, the EBIT figures in financial statements become more reliable, perhaps facilitating new ways to monitor business profitability with more holistic measures.

In the second recommendation, a decision is made to keep tracking sales margins on a variable costing level where only direct costs and variable overhead costs are considered. No changes or modifications are made to the existing product costing system. Fixed overhead costs are allocated independently to the balance sheet inventories as large-scale sums according to average operating and cost rates from past periods. IFRS IAS 2 only requires for financial inventories to include all manufacturing-related costs, therefore operative inventories and thus, product unit costs can remain solely as variable cost inclusive. This approach is certainly easier but will not offer the same level of stability for the company's EBIT as the first option does.

When choosing either option, the allocation process begins with the same initial step, where the fixed overhead costs related to manufacturing are carefully assessed. Depending on the chosen approach and accuracy of allocations, further investigations to causally link fixed overhead costs with cost objects must be conducted. This includes closely examining financial statements, conducting analyses, and engaging with a vast number of employees to form a clear ruleset of what fixed costs to allocate and to which costs objects. The goal is to have a ready description of the approach by end-of-year 2024. Overall, it is likely that some compromise will be developed to address benefits and drawbacks of each system. For example, easy-to-allocate fixed costs such as fixed salaries from modelling departments and operations managers are possible to allocate directly through the developed costing system with a good level of reliability, while other, more complex costs are allocated independently to the financial inventories.

6.3.2 Product costing development roadmap

After successful implementation of the TD-ABC system, a roadmap for future development actions was produced (Figure 37). The roadmap showcases the undelivered outcomes of the new costing system and highlights necessary plans of action to further improve the system in a continuous development approach. The roadmap consists of five distinct milestones which together lead to IFRS's IAS 2 compliant inventories, where financial inventories account for all manufacturing costs, also including fixed overhead costs. The end-goal of IAS 2 stock valuation is to be achieved by the end of 2025 and is a paramount goal for the case company's financial department. After implementing the TD-ABC system to all manufacturing units, gaining transparency to costs, and formulating a plan for steering the system dynamically, the first milestone will be achieved. Gaining transparency to costs is mainly conducted through finalizing the COGS cost split reporting to gain insights to the costs of the entire manufacturing process for each item. The primary goal for this phase is to implement the new product costing system in all manufacturing units by quarter 3 of 2024.

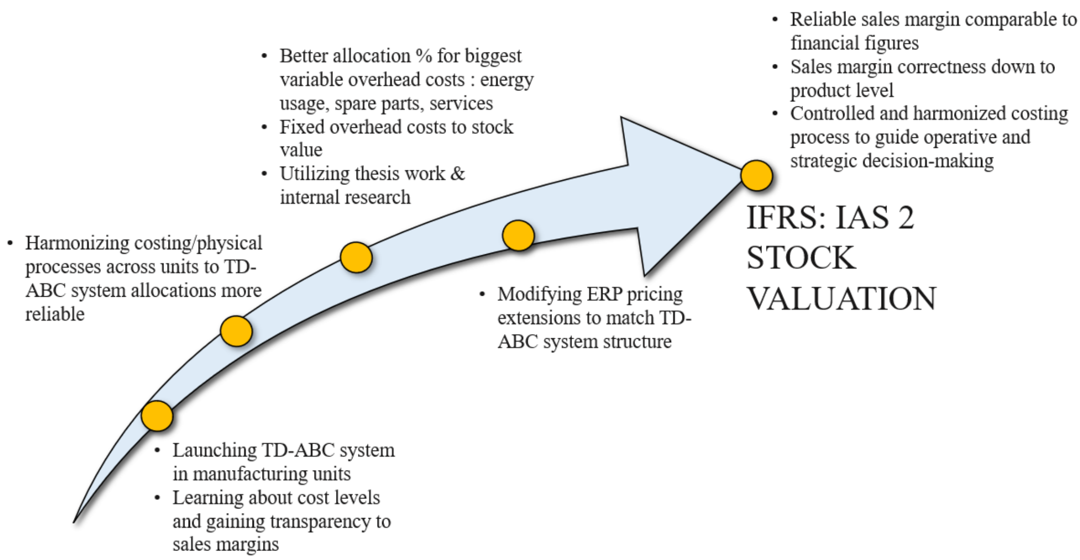

Figure 37: Product costing development roadmap

As the organization adapts to change and begins to utilize the developed system, the imperative is to focus on harmonizing the costing and physical processes across units to make comparisons between cost levels and to facilitate production decision-making. An important milestone is also improving the allocation percentage and accuracy of the biggest variable overhead costs, for example electricity usage, spare parts, maintenance, and services. Additionally, further automating the time driver calculation process will increase the reliability and uniformity of time drivers between units. Another key performance index for this milestone is the size of the general allocation pool of each unit. The goal is to minimize general allocations which affect a broad range of products, instead driving more costs to products through activity-specific time drivers. Also, developing a functional and rightful solution for allocating fixed overhead costs to inventories is paramount to reach the end-goal of IAS 2 inventories.

In the fourth milestone, there are two important tasks: modifying ERP-pricing extensions to match the TD-ABC system structure. The pricing extension works as a tool to make price offers for modified products. It currently operates with a similar structure as the developed TD-ABC system but with less detailed costing procedures and different time driver values. These two systems can however complement each other when a similar structure is configured. Having similar processes for estimating and costing the products will enable more efficient offer-making especially in times where margins are lower due to reduced market demand. It will also be easier to analyze sales margins on a product level to optimize offer pricing and learn about the true profitability of products.

The last step leading to IAS 2 level stock valuation in the case company requires all previously mentioned tasks and possibly other tasks not yet identified. Ultimately, the newly developed costing system will make sales margins more reliable and comparable to financial figures through detailed product-level data. Using a replicated costing structure across the organization will also positively impact the reliability and comparability of product cost data, creating an environment where business decisions can be made for the good of the whole organization, not just within individual units. This means that decisions can be made to shift production to different areas based on reliable profitability figures. Standardized costing and comparable product costs also affect the accuracy of internal transfer pricing which is an important part of subsidiaries businesses and profitability. In addition, customer offer-making processes are made more reliable as the true production costs can be accurately depicted. This is especially important with products that have extremely competitive markets and thus, sales margins are thin. Overall, the product cost data from a revised time-driven costing system paired with sufficient attention to steering enable the organization to gain flexibility in pricing as well as decision-making on both operative and strategic levels. Accurate product costs and harmonized processes are more important still during times when markets are unreliable and optimization opportunities are scarce.

7 Conclusions

7.1 Meeting objectives and answering research questions

This research aimed to enhance the internal reporting and decision-making of a manufacturing company by implementing a new TD-ABC system that considers variable overhead costs on a product level. The developed TD-ABC system also provided a practical method of moving towards IFRS IAS 2 standard inventories, in which all manufacturing costs, including variable and fixed overheads are included in the financial inventory value of goods. The constructed development framework (Figure 33) along with the comprehensive structure description (Figure 34) are the key results and artifacts of the utilized Design Science Research approach.

The main motivation of developing a new product costing system in the manufacturing company were threefold: sales margins and product profitability figures were unreliable, managerial, and financial reports were incomparable on certain levels, and both strategic and operative decision-making were hindered due to the lack of transparency in product costs. All the experienced issues were symptoms of existing variable overhead allocation methods and current reporting structures (Figure 19). The developed product costing system is a promising solution for addressing these topics, but independently not enough to fully eliminate them.

The research was constructed around three research questions to address all necessary perspectives of the research problem. Together the research questions aim to break down the complex nature of costing system implementation processes in manufacturing units, while focusing on the internal benefits gained from utilizing a new product costing approach. The research questions revolved around producing practical answers to the initial research problem. This chapter aims to unravel the research questions with practically grounded answers which closely relate to both the theoretical findings and empirical research conducted in the thesis.

1. *What specific aspects in the internal reporting of a manufacturing company can be improved by implementing a TD-ABC system which considers variable overhead costs on product level?*

The first research question focuses on the benefits within internal reporting when choosing a product costing approach which allocates variable overhead costs directly to products. Overall, the developed TD-ABC system can significantly improve the precision, reliability, and comparability of internal reporting by adopting a harmonized approach to allocate overhead costs. Additionally, the developed system was directly integrated to the ERP system and only requires systematic updates of time driver rates which are derived from general ledger entries, invoice processing and operative data (Figure 23 and Figure 34). The new TD-ABC approach will enable more reliable sales margins and enhance the comparability between managerial and financial reporting by providing direct allocation of variable overhead costs to product stock value (Figure 25).

2. *Which critical factors in the development of product costing systems are essential to ensure accuracy and reliability of variable overhead cost allocations?*

The second research question considers the critical success factors of product costing system development to facilitate accurate and reliable cost allocations. Firstly, choosing a suitable costing system which adheres to the complexity of operations and scope of overhead costs is a company-specific task which requires a great deal of consideration. In the case company's situation, a TD-ABC approach was deemed as the most reliable and accurate method due to the complex nature of manufacturing processes coupled with a relatively high level of different variable overhead costs (Figure 18). After the initial decision for a costing approach, the main factors affecting allocation accuracy and reliability were identified. In the case company, synchronization of physical processes with ERP system activities, accuracy of direct hour postings and continuous monitoring and dynamic responsiveness of the system were the most significant factors (Figure 26).

3. *What are the key stages in the development of TD-ABC systems in manufacturing environments, and how do they contribute to the system's practical applicability and subsequent effectiveness in decision-making?*

The final research question deals with the key stages of TD-ABC system development in manufacturing settings, and how they contribute to the system's practical applicability and effectiveness as a decision-making tool. In terms of improving the decision-making of the company through TD-ABC, recognizing time as the main driver of variable costs to combine both financial and operative measures is one of the clearest large-scale benefits. Viewing the organization's performance through similar measures on different organizational levels effectively aligns the workforce towards common goals and interests. Additionally, the refined cost data and transparency to product costs can be utilized in offer-making decisions, production relocation projects and to assess the development of manufacturing cost elements to better gauge operative and financial performance.

Considering the practical applicability of the TD-ABC system, it's necessary for the system to cater to the specific needs of the company. To accomplish a tailored costing system, the development process can be divided into 9 stages:

- Assess the current issues and objectives in product costing and reporting.
- Form a costing development team to establish process leadership.
- Identify manufacturing activities and establish cost pools.
- Evaluate causal relationships of costs and activities to calculate time drivers.
- Develop a basic TD-ABC structure and conduct testing.
- Identify technical, organizational, and managerial constraints of adoption.
- Develop solutions to overcome identified constraints and validate function.
- Implement the TD-ABC system in a pilot unit, aim to learn and replicate.
- Establish systematic ways of monitoring and controlling the system.

The practical implementation process was also examined independently (Figure 30). The practical implementation can be divided into five phases: preparation, workshop, validation, launch and monitoring. Each individual phase of the practical implementation process consists of both technical and stakeholder coordination tasks to successfully drive the proposed change throughout the organization. The implementation process timeline from initial preparation tasks to final launch was set to three months for the pilot unit but will be substantially shorter in the subsequent units after accumulating experience. Together, the identified key stages provide a standardized framework for system development which enhances the system's effectiveness and applicability. The stages are reviewed in a continuous fashion to iterate the development and specifically the implementation process for more effective system management.

7.2 Reflection on findings and comparison with previous research

The research has uncovered several valuable insights. Primarily, it demonstrated that integrating a TD-ABC system within an ERP is feasible and beneficial. This integration has paved the way for real-time, activity-based cost tracking that significantly refines product cost reports and additionally contributes to strategic and operative decision-making processes through utilizing time as a common driver of costs. Additionally, the system enables dynamic responsiveness to operating environment changes through a multifaceted approach in variable overhead allocation monitoring and control. The broader implications suggest that manufacturing companies could leverage this research to renew their cost accounting systems, thus driving industry-wide advances in cost management practices.

Despite its success, the research recognizes certain limitations, such as the complexity of aligning physical processes with system activities and ensuring the consistent accuracy of direct hour postings. In addition, current cost accounting procedures do not allow for perfect tracking of variable overhead cost expenditure within individual activities, causing issues with evaluating the causal relationships between costs and cost objects, and furthermore in allocation accuracy. Future research could explore the potential for artificial intelligence or machine learning algorithms to predict and adjust cost driver rates automatically, further reducing manual labor and improving the efficiency of the TD-ABC system. Additionally, the research did not resolve the issue of finding the best practical approach to allocating fixed overhead costs in compliance with IFRS IAS 2 standard inventories. Two different recommendations for tackling this issue were given, but further research is needed to weigh the benefits and drawbacks of both approaches, while assessing the possibilities for additional methods. Fixed overhead costs account for a 20 % share of the total manufacturing costs, and thus accurate allocation methods are needed. Further research into the practical usage of cost data in decision-making is also a viable topic to consider. Developing and implementing the TD-ABC system is not the main achievement from the company's perspective. Rather, the key deliverable of the development process is practical utilization of the system to expedite business performance through better decision-making.

This research corroborates the theoretical knowledge published by Drury (2004), Drury and Tyles (2005), Hilton (2008), Schoute (2009), which together underline the importance of evaluating a company's process complexity and scope of overhead costs when choosing a suitable costing approach. The overall goal is to effectively balance the costing system accuracy, usability, and reliability with the resulting costs of complexity arising from development, application, and maintenance of the system. Additionally, the research aligned with findings presented by Kaplan and Anderson (2004; 2007) regarding the benefits of TD-ABC systems in manufacturing environments as an accurate way of conducting overhead cost allocations. However, it also extends the dialogue by providing empirical evidence of these benefits in a real-world setting. The research also highlights the necessity for constant adaptation and monitoring to maintain the accuracy of cost allocations as cited by Hooijer (2023). The research identified similar limitations of TD-ABC system's practical utilization as outlined by Namazi (2016), especially regarding the allocation accuracy of fixed overhead costs through a time-driven approach. However, some of the highlighted limitations such as overestimation of practical capacity expenditure were eliminated by utilizing real-time posting features of the company's ERP system. The TD-ABC integration directly to the company's ERP system also aligned with findings from Kitsantas et al. (2020), which found direct integration to ERP as a method to facilitate more effective maintenance and management of the costing system. In general, the development process closely followed the example frameworks provided by Evaert and Bruggeman (2007), Gunasekaran (1999) and Kaplan and Anderson (2007), while overcoming the limitations of traditional product costing methods and conventional ABC approaches discussed by Askarany and Yazdifar (2009), Cooper and Kaplan (1998), Huang (2018), Kaplan and Anderson (2004), Monroy et al. (2012) and Tran and Thao (2020). The benefits from utilizing a TD-ABC approach as opposed to traditional methods or conventional ABC were similar than described by Areena and Abu (2019), Hooijer (2023) and Kaplan and Anderson (2004).

7.3 Theoretical and practical contribution

The theoretical contribution of the research lies in the validation of TD-ABC principles through conducting a practical development and implementation process in a selected manufacturing company. Additionally, challenging the role of conventional ABC with its various cost drivers while emphasizing the potential of time-driven approaches is an important contribution of this research. When looking at traditional management frameworks in manufacturing, top management primarily uses financial figures for monitoring, while operative levels utilize more detailed measures such as quantity, weight, shipments, and orders. Conventional ABC is built upon the traditional measures of operative levels. However, the goal of this research is to bridge the gap between top management and working personnel by utilizing time as a common measure and cost calculation principle. When considering the definition of variable costs, it’s understandable that in manufacturing and service industries alike, time is the most significant driver of variable costs. When operating rates and variable costs fluctuate, the change is primarily caused by changes in the time spent producing deliverables, which is an important connection to identify. The research indicates that distancing oneself from complicated cost drivers reliant on generic operative measures and instead focusing on using time as a main driver for variable overhead costs can effectively align the interests of both finance and operations departments in manufacturing and service industry players. In sum, viewing costs and activities through the same perspective on different organizational levels has significant potential to drive the company towards making better business-decisions, thus increasing performance.

The practical implementation and utilization of the system confirmed the viability and adaptability of an ERP-integrated TD-ABC system in a manufacturing setting. Overall, the hypothesis of improved internal reporting accuracy and reconciliation of internal and external reports was confirmed through a practical adaptation of the developed system. The practical contribution of this research is directly associated with the chosen manufacturing company, which now has a robust framework for developing and further refining their product costing system. The new system implies significantly better accuracy in product costs, sales margins, and profitability figures. Ultimately, the renewed product costing approach is an important step towards IFRS IAS 2 standard inventories in the case company, as well as a tool to facilitate operative and strategic decision-making. Socially, the research emphasizes the importance of transparency in cost reporting, which has potential to influence future regulatory standards both within and outside the manufacturing industry.

In conclusion, the successful adoption of a TD-ABC system has manifested in significant improvements for the case company, which can be replicated for other companies within the industry currently facing similar issues in product costing. Possibilities to expand the results to different sectors are also present. Overall, this research is a testament to the pivotal role of product costs, cost transparency and well-aligned cost performance indicators in organizational effectiveness and decision-making.

8 Summary

The goal of this research was to develop a TD-ABC system for allocating variable overhead costs in a select manufacturing company, and to produce a comprehensive development framework for the process. The case company of this research was experiencing issues with inaccurate sales margins and reconciliation of internal and external reports as well as unnecessary complexity in product cost calculations due to their existing approach in allocating variable overhead costs to products. The research was focused on simplifying the complex nature of developing and adopting a new product costing system by combining theoretical knowledge with industry expertise to create a proposed TD-ABC development framework for manufacturing companies. The research also compared the effects of variable costing and full absorption costing inventory valuation approaches, as well as how cost information is utilized in operative and strategic decision-making. The scope of research was confined to examine various costing methods in manufacturing companies with a special focus on activity-based costing in its various forms. Empirical data and practical findings were collected exclusively from the selected manufacturing company, and its TD-ABC development process. The system development process was conducted with finance and operations department personnel, with guidance from finance and IT consultants.

A Design Science Research (DSR) approach was utilized to facilitate experiential learning through close collaboration between the researcher and practical representatives of the company. The focus was to document the development and construct a standardized set of guidelines and practices for similar projects through reflecting the empirical findings to relevant literature.

The initial development process began by conducting research on activity-based costing applications in manufacturing settings. All key findings were documented, and functional development guidelines were studied for later use. The practical development started with an assessment of current product costing in the case company to map out the most important objectives and most influential constraints. The main objectives were listed as follows: accurate product level sales margins, compliance with IFRS IAS 2 inventories and better business-decisions through cost data. The main challenges were grouped into five categories with descending importance: correctness of physical processes, difficulties in steering the costing system, differences in accounting procedures, issues with governmental regulations among units, and lastly, other company-specific attributes.

A costing development team consisting of finance department employees was assembled to establish leadership for the development process. A time-driven activity-based costing approach was deemed as the best option given the goals and challenges of current product costing procedures. The team next focused on identifying and categorizing manufacturing activities and the scope of variable overhead costs. A total of 14 different manufacturing activity types were identified and associated with 5 different types of variable overhead costs. The activities were categorized based on their manufacturing process type into groups such as robot welding, manual welding, thermal cutting, forging, and machining. The variable overhead costs were grouped into labor, welding materials, paints, packing materials and other materials & services. The relationships between activities and overhead costs were used to form activity cost pools. The cost pools were further utilized to calculate time drivers for each activity based on their associated costs and expenditure of direct manufacturing labor hours. The time drivers of activities serve as the basis for allocating variable overhead costs to the stock value of products.

After calculating the time drivers, a basic structure for the TD-ABC system was developed and implemented to an ERP test environment. Technical, organizational, and stakeholder-related constraints were identified and solutions to overcome them were developed through engaging with employees and evaluating outcomes within the development team. Practical actions were taken together with operations and finance personnel to address the identified issues, and a continuous problem-solving approach was adopted to ensure successful implementation. A decision was made to launch the system in a pilot unit during the start of 2024, with subsequent implementations to remaining units by quarter 3 of 2024. An implementation process model with concrete tasks, schedules and responsible workers was constructed to facilitate smooth implementation. The TD-ABC system was successfully implemented in the pilot unit during March 2024. Monitoring and control guidelines were constructed to facilitate dynamic responsiveness and accuracy of the costing system. Local unit controllers were given a responsibility of monthly allocation status reporting and time driver updates according to mutually agreed calculation principles. The overall accuracy of overhead cost allocation is measured through assessing general ledger accounts, comparing time driver development between units, and evaluating the amount of variable overhead costs released through the cost of goods sold within each period.

A development framework with detailed implementation process steps for preparation actions, technical tasks, stakeholder engagement and organizational change was constructed as a key artifact based on practical experience and feedback from stakeholders. The TD-ABC costing system was developed to accurately and reliably allocate variable manufacturing overhead costs to product stock value. Allocated variable overheads include elements such as indirect labor, consumables, spare parts, maintenance, warehousing, electricity, and gases. The TD-ABC system was directly integrated to the company's ERP system and successfully implemented in a pilot unit by following the constructed guidelines. Overall, the new product costing system is effective and dynamically responsive to changes in the operating environment with monthly updated cost drivers. The system also facilitates harmonized product costing processes within the manufacturing units of the company, brings reliability and transparency to sales margins and helps reconcile financial statements and managerial reports.

The decision of developing the system further to progress from variable costing to full absorption costing is yet to be made. There are no significant technical restrictions on behalf of the developed TD-ABC system. However, the organization is likely not ready to switch from a variable costing approach to full absorption costing due to the loss of visibility to sales margins as operating rates fluctuate. Two recommendations were constructed to address this topic. Firstly, a new level of sales margin tracking could be created, in which fixed costs are included in the stock value of products but aren't displayed in managerial reports to keep sales margins as variable cost figures. Secondly, the organization can opt to continue calculating sales margins based on variable costs, while independently allocating overhead costs to the balance sheet through financial vouchers. Both options have their benefits and drawbacks, but either one will satisfy the organization's end-goal of IFRS IAS 2 compliant financial inventories. Further research needs to be conducted to assess the total impacts of either costing development approach.

In sum, the research validates TD-ABC principles through practical implementation in a manufacturing company, challenging the role of conventional ABC. It aims to bridge the gap between top management and operational levels by using time as a common measure for cost calculation. By focusing on time as the primary driver of variable costs, the study effectively aligns the interests of finance and operations departments. The practical implementation of an ERP-integrated TD-ABC system confirms its viability, improving internal reporting accuracy and reconciliation of internal and external reports. This contributes to a robust product costing framework, enhancing accuracy in costs, sales margins, and profitability figures. The study also highlights the importance of cost transparency, potentially influencing future regulatory standards. Overall, the successful adoption of TD-ABC in the case company suggests replicable benefits for similar companies in the industry and potential expansion to other sectors, emphasizing the critical role of cost transparency and key measure alignment in organizational effectiveness and decision-making.

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