The Role of Time-Driven Activity-Based Costing in Integrated Supply Chain Management

An Empirical Study of Modelling Operational Costs at 4PLs

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Submitted in Fulfilment of the Requirement for the Degree of

Doctor of Philosophy

Victoria University, Australia

Institute of Sustainable Industries & Liveable Cities

June 2023

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Abstract

Supply Chain Management (SCM) has been evolving remarkably since the 1980s as more businesses prefer to outsource their logistics activities to logistics companies. As a result, logistics companies have introduced more value-added services to satisfy their customers' needs. However, this service expansion is risky if logistics companies fail to accurately calculate costs. Previous researchers investigated the cost of logistics activities using different costing models, including the Time-Driven Activity-Based Costing (TD-ABC). However, most of these studies focus on traditional storage and transportation services and ignore the new services, such as Demand Planning and Procurement. There are three research aims for this research. First, to explore how the TD-ABC system can model the costs of integrated logistics activities in Fourth-Party Logistics (4PL) companies. Secondly, to find out how the TD-ABC system will differ from the traditional ABC system in modelling the logistics activities costs. Thirdly, to explore how the TD-ABC system can help logistics companies evaluate their customers' profitability in more depth than the profit and loss statement and the SC system report. A case-study design was used to conduct this research on a Saudi-based 4PL company. The researcher conducted six semi-structured interviews with the department managers at the case company to understand the business model, services, and customers in advance. Next, he observed the logistics operations for three months to estimate the steps and time needed to perform activities. Finally, he collected operational and financial records for Q1-2021 to develop a simulated TD-ABC system accordingly. This research shows that the TD-ABC system can accurately capture the cost of complicated and lengthy logistics activities. In addition, the TD-ABC model has been proven to be more accurate than the ABC model as it can distinguish between the costs of productive capacity and idle capacity. Finally, the TD-ABC system showed an excellent capability to be used as a tool for customer profitability analysis. In conclusion, this research should contribute to both knowledge and practice as it provides new insights on how to model the cost of new-era logistics services. A step-by-step guideline for designing a TD-ABC system in a 4PL company is presented in this research, and it can be used as a model by new researchers and practitioners. Moreover, by exploring the Open-Book Accounting (OBA) practice within the 4PL sector, this study unveils a novel perspective on cost transparency and cooperative financial relationships between logistics companies and their clients, enriching the discourse on financial management in modern logistics operations. Finally, this research introduces a new framework that synergies TD-ABC with the company’s vision. This study positions the proposed framework as a foundational idea for future studies that aim to bridge the gap between cost data and the company’s strategic goals, especially in the 4PL industry.

Keywords: TD-ABC, Logistics management, 4PL, ABC, customers profitability analysis, OBA

Declaration of Authorship

I, Khalid Alahmari, declare that the PhD thesis entitled *The Role of Time-Driven Activity-Based Costing in the Integrated Supply Chain Management* is no more than 80,000 words in length, including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

I have conducted my research in alignment with the Australian Code for the Responsible Conduct of Research and Victoria University's Higher Degree by Research Policy and Procedures.

Ethics Declaration

All research procedures reported in this thesis were approved by the Human Research Ethics committee HRE20-132

[redacted]

Signature Date 5/11/2023

Dedication

To my Lord, Allah, for the power and capacity He had granted me to complete my PhD,

To the great homeland that I've been raised and learned in, and to its government that sponsored this study, the Kingdom of Saudi Arabia,

To those who raised me, my father (may Allah's mercy be upon him) and my mother,

To my lovely wife Hadeel, whom I leaned on in my weakness,

To my supervisors, Sophia, Colin, and PariSima,

To my brother, sisters and friends.

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Abbreviations	Definition
2PL	Second-Party Logistics
3PL	Third-Party Logistics
4PL	Fourth-Party Logistics
5PL	Fifth-Party Logistics
7 R's	Seven-Rights Concept
ABC	Activity-Based Costing
ABM	Activity-Based Management
ADC	Automatic Data Collection
BRCGS	British Retail Consortium
BSC	Balanced Scorecard
CBM	Cubic Metre
CCR	Capacity Cost Rate
CML	Council of Logistics Management
CPA	Customer Profitability Analysis
CSCMP	Council of Supply Chain Management Professionals
CTS	Cost-to-Serve
DQMP	Distributor Quality Management Program
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
FOA	Form of Acceptance
GL	General ledger
GRN	Goods Receiving Notes
GSCF	Global Supply Chain Forum
HR	Human Resources
IT	Information Technology
LSP	Logistics Service Provider
OBA	Open-Book Accounting
P&L	Profit and Loss Statement
Q1-2021	Quarter One in 2021
QIP	Quality Inspection Program
RFID	Radio Frequency Identification
RP	Resource Pool
SC	Standard Costing
SCM	Supply Chain Management
SCOR	Supply Chain Operations Reference
SCS	Supply Chain Supervisor
SFDA	Saudi Food and Drug Authority
SKU	Stock Keeping Unit

SMEs	Small and Medium-Sized Enterprises
SPPF	Strategic Performance and Profitability Framework
TD-ABC	Time-Driven Activity-Based Costing
VCM	Value-Chain Management
WMS	Warehouse Management System

Chapter 1 : Introduction

As the pace of global business continues to increase, Supply Chain Management (SCM) has become increasingly complex and challenging (Christopher, 2016). Companies must optimise their cost structures while managing their supply chains effectively. One effective strategy for achieving these goals is outsourcing, which allows companies to focus on their core competencies while offloading non-essential tasks to external vendors (Daim et al., 2013).

While outsourcing can be an effective way to improve efficiency, it also comes with risks for the outsourcing companies. Lambert et al. (1998) suggest that outsourcing could mitigate control and flexibility over logistics activities. In addition, it may cause difficulty in communication with clients directly, which could result in losing important information when relying on third-party logistics (3PL) (Abdur Razzaque & Chen Sheng, 1998). Direct communication with clients will be mediated by a third party who will, sometimes, be acting as a customer service company beside its core role as logistics company.

On the other hand, as logistics companies continue to grow and expand their operations to meet their client's needs, they are faced with increasing costs and risks that can negatively impact their bottom line. Lieb and Bentz (2005) surveyed the CEOs of the top 25 logistics companies in North America who agreed that there is high pressure continually coming from clients to reduce the logistics services rates. Clients, according to the participants, don't appreciate the true value of services and high investments demanded in infrastructure and talent. This pressure requires logistics companies to adapt advanced costing systems that can generate accurate cost information while maintaining high levels of efficiency and quality to meet the clients' requirements.

For businesses with complex operations such as logistics, having reliable cost data is essential to make informed decisions regarding operational processes and resource allocation (Anderson & Kaplan, 2007). Kaplan and Anderson (2004) claim that Time-Driven Activity-Based Costing (TD-ABC) is an ideal approach for accurately capturing these costs, as it considers the resources (e.g. time) required to complete different activities within the operation. Using this approach, organisations can gain insights into where they can streamline their processes and improve resource allocation, ultimately helping them to become more efficient and competitive in their field.

1.1 Research Background

1.1.1 Supply Chain Management

More than 60 years ago, the seed of the term Supply Chain Management (SCM) was planted when (Forrester, 1958) introduced the distribution management theory that recognised the importance of "the Integra recognised of organisational relationships" (Mentzer et al., 2001, p. 1). Forrester claimed, in his revolutionary study *Industrial Dynamics* that the success of industrial companies will depend on how they understand the flow and interactions between five elements: information, stock of inventory, money, labour, and capital equipment. Interestingly, he predicted that success in businesses would be in favour of the companies that work hard on improving and understanding the long-term relationships between the different functions inside the company, between the company itself and the market and industry, and between the company and the national economy as a whole (Mentzer et al., 2001).

Since the introduction of Forrester's theory, there was no explicit effort to define the term SCM until the 1980s, when firms had realised the importance of collaborative relationships among suppliers and customers. As a result, the term SCM started to spread steadily (Lummus & Vokurka, 1999). Since then, many definitions have been proposed by researchers and practitioners in attempts to establish the foundations of this new knowledge and to explain its boundaries with other relative disciplines. This effort can be noticed through the remarkable rise of the usage of the term SCM on Google Books Ngram Viewer where tremendous growth in the emergence of this term can be found in published English books in the period from 1800 to 2019 (Figure 1-1). However, these efforts needed to be unified to agree on a definition. In 2005, the Council of Supply Chain Management Professionals (CSCMP) surveyed its members to define this new discipline, and that initiative resulted in the following definition:

> “Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, Supply Chain Management integrates supply and demand management within and across companies.”

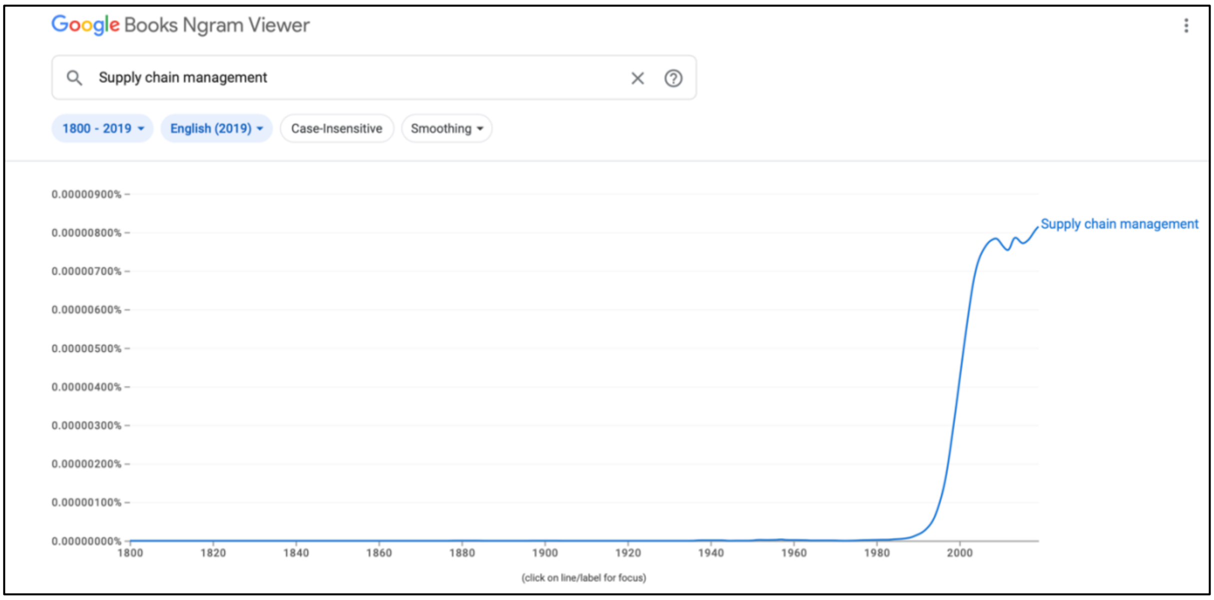

Figure 1-1: The SCM term growth in English books since the 1800s

The Role of SCM in economy

Supply chain management is a crucial component of today's economy (Liu et al., 2022), which is essential in ensuring the efficient and effective flow of goods, services, and information throughout the supply chain (Gen et al., 2021). This process requires careful coordination between supply chain partners, from manufacturers and distributors to retailers and consumers, to ensure that goods and services are delivered on time and at the correct price. Given its central role in today's economy, supply chain management is increasingly recognised as a critical and strategic variable (Copacino, 2019). Businesses that fail to optimise their supply chain operations in line with industry best practices can fall behind their competitors (Ochonogor et al., 2022), losing crucial revenue and market share.

However, supply chain management is not without its challenges. For one thing, supply chains are becoming increasingly complex as supply chains grow more extensive and more globalised (Freichel et al., 2022). This makes it more challenging to monitor the flow of goods and information throughout the supply chain, which can lead to supply disruptions and other costly inefficiencies (Freichel et al., 2022). One way to overcome these challenges is to outsource the logistics activities to a third-party logistics company that can have higher competencies and better infrastructure to handle this complex operation (van der Westhuizen & Niemann, 2022).

Outsourcing

Over the past few decades, there has been a trend towards outsourcing logistics to logistics companies (Vasiliauskas & Barysienė, 2008). Damme and Amstel (1996) defined the reasons that encourge companies to outsource their logistics activities to logistics services providers. First, the desire to save costs and streamline operations and the increasing complexity of logistics processes. By outsourcing their logistics operations to third-party logistics companies, businesses can benefit from their extensive experience and expertise, as well as their advanced technology and infrastructure. Additionally, outsourcing logistics can allow businesses to focus more on their core operations and less on day-to-day logistics tasks (Damme & Amstel, 1996).

SCM vs Logistics

The literature on SCM shows that the term SCM is broad and, to some extent, ambiguous. Part of this issue could be attributed to the novelty of this discipline. Some professionals and academics still confuse the terms SCM and logistics management. The two terms seem, to many, synonyms, whereas they are not. Cooper et al. (1997) argue that the SCM should go beyond logistics and include all business processes from the origin of products, services, and even information to the point of consumption.

On the other hand, logistics is more concerned with the movement and storage of goods, services, and information. In other words, logistics concentrates on one part of the SCM function, which is the storage and flow of Objects. Cooper et al. (1997) claim that this confusion was justifiable since the SCM definition had not been found in the literature until 1982; Cooper et al. (1997) state that academia must lead the business practice to correct this misconception and develop a broader definition for the SCM since it includes more functions than logistics.

1.1.2 Management Accounting

Standard Costing (SC)

In management and cost accounting, there are two main types of costs: direct[1] and indirect[2]. While the former are easy to trace and allocate, the latter are challenging to most companies as they represent the sharing of costs that cannot be traced and allocated directly. Several models and methods have been found in the literature discussing this challenge. One of the leading models widely adopted is Standard Costing (SC). The adoption of this model started in the late nineteenth century when the industrial engineers in the UK and US promoted the modern managerial techniques to monitor and control the performance of large mass-production factories (Fleischman & Tyson, 1998). The idea of this model is that each department divides the total overhead cost (nominator) by one or a few cost drivers (e.g. machine hours) to obtain the

[1] The expenses that can be directly attributed to the production of a specific product or service (e.g. materials)

[2] The expenses that are not directly attributable to the production of a specific product or service but are necessary for the overall operation of a business (e.g. utilities and rent)

overhead cost rate for that department. For example, if department A had a total of $100,000 as overhead cost in January, and the total number of machine hours was 100,000 hours, the overhead cost rate for department A is $1 per machine hour. If customer X requires 100 hours of machine work, the department should charge that customer $100 or more. Unfortunately, this model has become non-viable since the technology has flipped the direct-and-indirect costs equation. Most costs in modern companies are indirect, and they require multiple cost drivers. In addition, automation and intensive customisations have resulted in more complexity in the activities inside operations. Companies then moved into Activity-Based Management (ABM) techniques to capture this change in the cost structure and behaviour.

Activity Based Costing (ABC)

In the late 20th century, the ABC model was invented to adapt to the impact of technologies on the business cost structure (Johnson, 1992). In contrast to the SC model, which allocates overhead costs from departments to cost objects (such as customers, products, etc.) directly, the ABC model uses activities as the hub of the allocation process. Back to the previous example of department A, instead of allocating the overhead cost to customer X based on the number of machine hours utilised, the ABC system divides the total overhead cost of department A into multiple portions depending on the number of activities in that department. For example, if there are three different activities that department A is implementing, the system divides the $100,000 overhead cost among these three activities based on the workload that each activity consumes. If activities X, Y, and Z consume 30%, 50%, and 20% of the total department's capacity, respectively, the ABC system will allocate $30,000 to activity X, $50,000 to activity Y, and $20,000 to activity Z. Next, each activity should have one cost driver that assigns costs from the activity to the cost objects (similarly to SC).

However, as business needs change continuously, some pitfalls in the ABC model were discovered and reported. Santana et al. (2014) claim that this system is often viewed as complex and costly; thus, 90% of companies that adopted it abandoned it at some stage later. Kaplan and Anderson (2004) state some main issues with the ABC system. First, the ABC model requires a huge amount of data to develop as it needs information about activities and their cost drivers. In some large companies, the number of activities can reach the level of thousands of activities. That means thousands of cost drivers must be selected and configured in the system. Secondly, this system relies on surveying people to estimate the departments' workload distribution. Every month, the cost controller needs to interview key people from each department to allocate the cost of departments to activities, based on their judgement. Besides the hassle of collecting such massive data every month, the system is prone to subjectivity, where personal judgements cannot be accurate. Thus, the accuracy of cost information generated by this system will be affected. Finally, the ABC system assigns 100% of the departmental overhead costs to activities. That means the system includes any idle capacity cost in this allocation. The cost objects (e.g. customers) will be charged for the cost of non-productive times that they are not responsible for. These reported flaws encouraged (Kaplan & Anderson, 2004) to improve the ABC model and use a different mechanism to run the costing system easily and efficiently, which is discussed in the next section.

From ABC to TD-ABC

As mentioned in the previous section, the ABC system failed to prove its feasibility in many companies for the aforementioned shortcomings. Kaplan and Anderson (2004) developed a new allocation method that inherits the ABC DNA but in a new and more straightforward way. The TD-ABC system was designed to replace surveys with time as the heart of allocation. Consequently, instead of surveying teams about their workload distribution, the TD-ABC model employs equations to estimate the time needed to perform the standard process, along with potential variations that might occur in some scenarios (See Equation 1.1). For example, in the activity of "Processing Sales Orders", the equation calculates the time needed to process a standard sales order. Moreover, it can account for variations in that order stemming from factors such as delivery terms, payment terms, number of lines, type of customer, etc. (See Equation 1.2). This straightforward inclusion of variations was absent in the traditional ABC model, which requires expanding the dictionary of activities with each variation (Anderson & Kaplan, 2007).

$$\text{Activity "X" (minute)} = T + (V1*X1) + (V2*X2) + (V3*X3) + \ldots + (Vn*Xn)$$

Equation 1-1: An example of the TD-ABC equations

where:

T: Standard time to perform Activity "X",

V1, V2, V3…: variations/subactivities ,

T1, T2, T3…: variation/subactivity times (if required).

By applying the generic equation above on the example of "Processing Sales Orders" activity:

Processing Sales Orders (minute): 10 + (2 * number of lines) + 5 if a new customer + 3 if special packaging + …etc.

Equation 1-2: Processing Sales Orders time equation (numbers are examples)

Next, the Time-Driven Activity-Based Costing (TD-ABC) system calculates the Capacity Cost

Rate (CCR) on a per-minute basis. This is achieved by dividing the department total overhead costs by its practical capacity, which is the number of minutes available for work in that specific department. These two key parameters—time and CCR—provide a robust foundation for accurately allocating overhead costs, first to activities and subsequently to cost objects. To illustrate, consider the sales department with a practical capacity of 100,000 minutes per month and total overhead costs amounting to $500,000 per month. In this case, the cost per minute would be calculated as $5, derived from dividing the $500,000 overhead costs by the 100,000 available minutes. Further, if the activity Processing Sales Orders consumed 90,000 minutes in the previous month—a metric typically available in Enterprise Resource Planning (ERP) systems—then the cost associated with this activity would be $450,000 for that month. Additionally, if Customer A utilised 1,000 minutes of this activity time, the system would allocate a cost of $5,000 to that particular customer.

The TD-ABC methodology offers not only a way to calculate the cost of activities and objects but also other benefits that can be obtained when implementing this system. For example, since the TD-ABC system uses the time as a cost driver, this model allows to estimate the unused capacity in each department, thus the cost of utilised resources. For example, if the Sales Department has 100,000 minutes as practical capacity per month, and if it used only 90,000 minutes processing sales orders last month, that means the remaining 10,000 minutes were unused capacity. The cost of this idle capacity would be $50,000 (10,000 minutes * $5 per minute), accordingly. Another advantage in the TD-ABC system is that the management can have a better visibility on the types of activities that being performed. Non-added value activities will be eliminated to free up more practical capacity to perform valuable activities that bring more business and satisfaction. Finally, TD-ABC system allows for more accurate insights into the customers profitability. Since the overhead costs can be allocated from activities to customers based on the amount of time consumed by each customer, that gives the management a clearer vision on how each customer contributes to the company's overall profitability. Such insights assist significantly in several domains such as pricing, customer relationship management, mangaing product mix, etc.

As with any other system, the TD-ABC is not free of flaws. Previous studies reported some challenges associated with TD-ABC implementation. Afonso and Santana (2016) criticise TD-ABC because of the massive need for time data, which may result in inaccurate cost information. In the implementation process, the system developer must collect time data through interviews with teams or direct observations. However, this step may become a source of bias, especially in the case of interviews. Cardinaels and Labro (2008) found that 77% of employees overestimate the time of processes by 33%. When observing teams during work, the data will be more accurate, especially when repeated observations are averaged. However, this leads to another issue, which is the teams' resistance to implementation or being uncomfortable with the observations (Gervais et al., 2010; Reddy et al., 2012). The suggested solution to these implementation issues can be found in the automatic data collection tools (Varila et al., 2007). Such tools can collect actual time data from the company's ERP to use for the TD-ABC allocation. However, most companies, especially small and medium-sized enterprises (SMEs) cannot afford such advanced technologies. This may hinder the adoption of the TD-ABC systems among millions of organisations in the world.

Customer profitability analysis

In today's competitive business world, companies need to adapt advanced profitability analysis tools. Such tools serve as a compass that guides management to understand their financial health, identify growth opportunities, and touch areas that need intervention. The comprehensive profitability tools allow businesses to delve deep into the operational and financial data, making it possible to discover data patterns and trends, thus informing decision-making for the long-term needs (Everaert et al., 2008). Such insights are crucial for strategic planning, resource allocation, and market expansion. Furthermore, having robust profitability analysis tools ensure that businesses can communicate their financial performance effectively and confidently (Lahutta & Wroński, 2015).

Customer profitability analysis (CPA) is a pivotal tool that addresses the aforementioned needs, assisting management in making informed decisions about resource allocation, pricing strategies, and customer relationship management (Adıgüzel, 2023). Furthermore, integrating CPA with TD-ABC system refines this analysis and enhances the quality of outcomes (Järvinen & Väätäjä, 2018). The TD-ABC system provides a detailed breakdown of cost data based on the actual resource consumption for each customer. As a result, management can obtain a granular view of each customer's profitability, whether on an individual or segment level (Everaert et al., 2008). This synergy between CPA and TD-ABC offers decision-makers insights into the customers behavior and contributions to the bottom line. Consequently, it enables them to optimise services and tailor marketing strategies in a manner that maximises profitability and customer satisfaction (Lahutta & Wroński, 2015)

1.2 Research Problem

As discussed earlier, logistics companies are expanding their services to meet growing customer demands. Many logistics companies have pivoted their standard business models to more advanced ones to secure a rewarding market share. However, this onward development in supply chain management practices is risky for logistics companies if they fail to financially measure and control the results of their operations. Cost information should be accurate and up to date so managers can make the right decisions at the right times. “Accurate costing is the base for all supply chain decisions.” (Lawson, 2017, p. 9)

In reality, there is a considerable gap between developments in supply chain practices and management accounting practices. Christopher (2016) states that there is dissatisfaction in logistics management regarding cost accounting due to some problems associated with costing systems. The researcher claims that logistics companies suffer from a lack of cost information visibility and accuracy. Conventional cost systems, such as SC, ignore the detailed and actual cost of servicing different segments of customers, channels, or markets. Instead, they focus on the general cost of operation at a high level of aggregation. In addition, these systems focus mainly on product cost analysis more than customer profitability, preventing managers from appropriately assessing the supply chain relationships. In short, conventional cost systems fail to adapt to new developments in logistics operations and challenges in supply chain practices. As a result, some logistics companies find it difficult to expand and provide integrated supply chain services because of the lack of cost information visibility (Christopher, 2016).

Anderson and Kaplan (2007) claim that the TD-ABC system can bridge the gap between management accounting and supply chain management. The researchers proclaim that this system can capture the root causes of costs in complex logistics operations. Thus, it can help managers evaluate the cost of their customers and services and understand the causes of variation in resource consumption. By adopting the TD-ABC system, management can measure the cost and profit by multiple dimensions beyond products and services. Decisionmakers can evaluate the results of operation per stock keeping unit (SKU), channel, customer, supplier, order, and more. “These detailed data enable the enterprises to determine the root causes of costly and unprofitable supply-chain relationships” (Anderson & Kaplan, 2007, p. 119).

In the supply chain management literature, there is a lack of studies investigating the TD-ABC system’s role. The existing studies that discuss this role can be divided into two groups. The first group is for studies aiming to understand TD-ABC’s role in modelling logistics activity costs in companies working in other industries, such as health care, trading, manufacturing, and construction. The second group represents studies focusing mainly on TD-ABC’s role in logistics companies. Such studies, however, restricted their scope to 2PL- and 3PL-based services, such as warehousing, order fulfilment, and transportation. In the only study found discussing 4PL services (Danomah, 2021), discusses the role of the TD-ABC system in modelling the procurement activity costs in a 4PL company. However, this activity does not adequately represent the complexity of modern logistics operations where customers prefer to outsource the entire logistics activities to

3PLs and 4PLs, who started providing more added-value services to meet this demand. However, this expansion could negatively impact the logistics companies' profitability if they fail to capture the actual cost. Therefore, this study attempts to discover the role of the TD-ABC methodology in helping logistics companies, specifically 4PLs, to overcome this challenge by modelling the actual costs of integrated supply chain services.

1.3 Research aims, objectives, and questions

The discussion above can lead us to conclude that there is a gap in the literature when it comes to the role of TD-ABC in modern logistics companies, such as 4PLs, that provide integrated supply chain services. This type of company often needs a more sophisticated model to capture the actual cost of operation along the supply chain. It also needs this model to evaluate its customer profitability in more depth. Therefore, this study aims to bridge this gap and connect management accounting and supply chain management with empirical evidence from a 4PL case company. Accordingly, the researcher sets out several aims, objectives, and research questions as follows.

- To explore how the TD-ABC system can model the costs of integrated logistics activities in 4PL companies.
- To find out how the TD-ABC system will differ from the traditional ABC system in modelling the logistics activities costs.
- To explore how the TD-ABC system can help logistics companies evaluate their customers profitability in more depth than the profit and loss statement and the SC system report.

1.3.1 Research Objectives:

- To visualise the process of logistics operations in a 4PL company and to develop a simulating TD-ABC system that can capture the cost of these processes accordingly.
- To develop a simulating ABC system and to compare it with the TD-ABC system in terms of the development process and the systems' outcomes.
- To compare the profitability reports generated by the TD-ABC system with those generated from the financial profit and loss statement and the SC system.

1.3.2 Research Questions:

RQ1 – How can the TD-ABC system model the costs of integrated logistics services in a 4PL company?

RQ2 – How will the cost information generated from the TD-ABC system differ from that generated from the traditional ABC system?

RQ3 – How can the TD-ABC model help logistics companies improve the quality of the cost and profitability reports?

1.4 Research Methodology

To meet the aims of this research and answer its questions, the researcher adapted the case-study methodology to collect qualitative and quantitative data necessary for the development of the TD-ABC system. This methodology is robust for understanding events in their contexts, where logistics activities need an in-depth investigation and observation to understand their causes and the sources of variation in the resource consumption (Stake, 1995). Rowley (2002) claims that this methodology is powerful in answering How and Why questions as it supports the researcher in investigating the evidence to find the research answers. Therefore, it is effectively illustrative in similar studies such as those of Everaert et al. (2008); Gervais et al. (2010); Kim et al. (2016); Somapa et al. (2012); Ma (2014).

A single-case company from Saudi Arabia was selected for this research. The single-case study approach is practical when the researcher aims to deeply investigate an existing phenomenon, especially when the selected case represents typical objects (Yin, 2003). The selected company can meet this criterion as it has been certified by the well-known global supply chain assurance organisation (BRCGS) for its compliance with the global standards for storage and distribution. The company provides 2PL, 3PL, and 4PL services to its customers. As this research aims to investigate the role of TD-ABC in modern logistics companies, the scope of this research includes the 4PL services such as demand planning, procurement, warehousing, order fulfilment, delivery, costing, claims management, and more.

The researcher collected quantitative and qualitative primary and secondary data through multiple means. First, he conducted semi-structured interviews with the department managers at the case company. The goal of these interviews is to have a better understanding of the company's processes, services, and customers. Next, the researcher spent around three months (five days a week, three to four hours a day) observing the logistics operations in the case company's facilities. These observations aimed to estimate the times and steps required to implement services. Finally, the researcher collected data from the enterprise resource planning (ERP) system, including the general ledger, operational logbook, HR records, and more. These documents were necessary to develop and run the TD-ABC simulating system built using Microsoft Excel.

The researcher selected Q1-2021 as the study analysis sample. The reason behind this selection is that it is the same period of data collection. Therefore, data will become more representative of the research data collection tools. The researcher used (Kaplan & Anderson, 2004) three main steps to develop the TD-ABC system. However, these three main steps were expanded in this study to seven steps. The researcher disaggregated the main steps into more steps because he needed this research to become a guideline for future researchers interested in the TD-ABC model development. In addition, he aimed to add more validity to the research outcomes by making the research more evident and easier for replication. Microsoft Excel was used also to build the ABC simulating system for comparison with the TD-ABC one. However, this model is limited to one department with four activities only. The comparison between TD-ABC and ABC systems aims to highlight the general differences between the two systems rather than the details of cost information per department. Finally, the researcher used the existing cost and profit reports available at the case company for comparison with the TD-ABC outcomes to explore how the latter can provide more quality reports to the decisionmakers in organisations.

1.5 Research Contributions

This study contributes to the management accounting and supply chain management literature and practice in a novel way. A comprehensive review of the prior literature was undertaken, which did not reveal a similar study that discusses cost modelling for a wide range of integrated supply chain services. The TD-ABC system developed in this research succeeded in modelling the operational costs in a 4PL case company. Activities such as demand planning, procurement, claims management were discovered and modelled in this research while the previous studies (Bahr, 2016; Danomah, 2021; Everaert et al., 2008; Flick et al., 2014; Kim et al., 2016; Ma, 2014; Somapa et al., 2012) developed TD-ABC models for only traditional 2PL or 3PL services, such as warehousing, order fulfilment, and delivery.

Secondly, since this research models the cost of 4PL activities from end-to-end using the TD-ABC methodology, discoveries were found in this research regarding the feasibility of this methodology when applied in the 4PL logistics operation. For example, it has been found that the TD-ABC application is more complicated with activities requiring thinking, communication, and planning, such as demand planning, than activities that heavily dependent on physical movements such as order fulfilment and delivery. This finding supports the claim made by Cheporov and Cheporova (2014) that TD-ABC could not be suitable for activities that require “forethought and creative thinking”.

This research aims to develop a TD-ABC system for costing and then an ABC system for comparison with the former, which could contribute to the body of management accounting literature in a new way. Contrary to the previous studies that examine the differences between TD-ABC and ABC systems from the advantages and disadvantages point of view such as those reported by Cheporov and Cheporova (2014),Hoozée et al. (2010), and Zamrud and Abu (2020), this research shows the step-by-step development process for each system. Similarities and differences between these systems were emphasised. For example, the researcher found that the TD-ABC requires more effort from the system developer to collect data than the ABC, which relies more on the participant judgements. However, since data in the TD-ABC system were collected mainly through repeated observations, this system shows more information reliability than ABC. In addition, TD-ABC shows more flexibility than ABC when it comes to updating the system.

Anderson and Kaplan (2007) and Smith and Dikolli (1995) argue that customer profitability analysis is more important than product profitability analysis for service companies. This research validates this statement by examining customer profitability in a distinct case. As outlined in the methodology section, the researcher selected one case customer for this research. This customer had seven outlets in Q1-2021. All branches consume the same products and demand the same services from the case company. Someone may suggest that the cost pattern among the seven branches will be linear. In other words, the most demanding branches will incur more costs. However, this study shows that some branches had less profitability contributions than others (percentage-wise) although they had larger sales volume. The underlying reason, as identified in this research, stems from the operational characteristics of branches. This observation aligns with Smith and Dikolli (1995) assertion that serving one customer with multiple branches introduces its own set of complexities. This insight underscores the importance of customer profitability analysis for service companies, especially logistics. Furthermore, the TD-ABC system emerges as an invaluable tool for this purpose, given its ability to allocate costs based on the specific attributes of orders, shipments, products, etc.

This study sets out to shed light on the Open-Book Accounting (OBA) practice within the 4PL industry while homing in on considerations specifically related to cost-plus pricing. In contrast to former research these efforts further clarify the role of OBA in a 4PL environment, giving newfound insight into the existing knowledge base concerning supply chain management and logistics. One particularly worthwhile concept explored herein is TD-ABC as a model proven to amplify transparency with respect to open-book contract costs. This aligns with Caglio (2018) assertion that OBA necessitates a sophisticated cost accounting system to produce accurate and shareable cost data. Seal et al. (1999) further underscored the importance of robust internal cost systems, suggesting tools like ABC and the balanced scorecard (BSC) to measure intra-company costs and define non-financial benefits among OBA partners.

Drilling down into the association linking TD-ABC and OBA, this study highlights how 4PL companies can nurture clear and collaborative relationships with their clients. Such insights can bridge the literature gap, especially in understanding financial dynamics in 4PL operations, as seen in sectors like automotive (Fehr & Rocha, 2018) and manufacturing (DhaifAllah et al., 2019), where OBA has been instrumental in fortifying trust and facilitating information dissemination. Hence, this research truly serves as a stepping stone for others aiming to delve deeper into the financial dynamics of 4PL services and is thus meaningful for discussions surrounding supply chain management and management accounting.

Finally, the logistics and supply chain industry needs tools that can help companies gain further insight into their current performance while also planning for the future. In introducing the brand-new Strategic Performance and Profitability Framework (SPPF) concept that combines three important tools—TD-ABC, the Customer Profitability Analysis (CPA), and the Balanced Scorecard (BSC)—this research injects a novel idea into the world of academics as a means to connect daily task costs with larger company goals (most notably for businesses in the 4PL sector). By depicting these three analytical and strategic tools in one framework, the SPPF offers valuable insights for both scholars and industry professionals, enriching the supply chain practice and literature.

1.6 Management Accounting Research Approaches

In any discipline, researchers can follow different approaches to reach conclusions that serve their aims. Management accounting is no exception. (Scapens, 1991; Scapens et al., 2002) identified five research approaches that can be observed in management accounting literature: traditional (economic-based), behavioural, derived from Organisational Theory, derived from Social Theory, and practice-oriented research. Regarding the last one, Scapens et al. (2002) claim that this approach emerged to fill the gap between theory and practice. It describes management accounting practice and doesn't aim to testify or justify theories. Zimmerman (2001) criticises this aim as it doesn't add any value to the theory. "The empirical managerial accounting literature has failed to produce a substantive cumulative body of knowledge." (Zimmerman, 2001, p. 411).

Ittner and Larcker (2002) disagree with Zimmerman's opinion, claiming that accounting is an applied science that should focus mainly on improving practices. "It is difficult to imagine how research in an applied discipline such as managerial accounting could evolve without the benefit of detailed examination of actual practices." (Ittner & Larcker, 2002, p. 788). Many researchers in the management accounting literature, such as those that discuss balanced scorecards, ABC systems, and compensation practices, have added great value to the literature by testing the practices of consultants and managers in a scientific way (Ittner & Larcker, 2002). Such practical research opened new doors for future researchers to improve the economy's status quo. Ignoring the study of recent practices by managerial accounting researchers will increase the gap between theory and practice. Consequently, researchers will lose their relevance and value in the ecosystem.

1.7 Research limitation

This research aims to explore the role of the TD-ABC system in the logistics companies that provide integrated supply chain services. The researcher used the single-case study to develop a TD-ABC for a case 4PL company. The researcher observed and analysed processes that occurred in that company in Q1-2021. This short period may not represent the actual status of logistics operations as logistics can be affected by seasonality. However, due to the time limitation of this research project and the COVID restrictions in 2020 and 2021, the researcher was unable to extend this project's duration or modify the chosen period. Further details about data collection challenges can be found in Chapter 5, in Section 5.1.4, Page 94.

Another limitation in this research is associated with the observation sites. The researcher observed the operations that occurred in the case company's head office and central warehouse. The outcomes of data collected from these locations were replicated to the other locations assuming that all facilities follow the same procedures. However, discrepancies may appear between locations, and that is worth more investigation. The researcher was unable to observe the operations in different locations as they were in different cities. The project's time and resources were not enough to expand the geographic scope.

Although the case company served around 15 clients in Q1-2021, this research focuses on only one customer, which may be considered as another limitation. The integrated supply chain services were provided by the case company to only two customers out of the 15 customers while the other 13 dealt with the case company for 2PL and 3PL services. From the two available 4PL customers, the researcher selected one and dropped the other which had less business with the case company. The researcher investigated the integrated supply chain services from the demand planning phase to invoicing. This wide scope was applicable only to the selected case customer. To avoid this limitation's consequences, the researcher analysed this case customer's branches as separate entities, to compare the cost and profit outcomes between them.

This research aims to explore the role of TD-ABC model in the 4PL realm. The researcher developed a simulated TD-ABC model for a case company that lacked any advanced costing system. It is worth noting that the development of such simulated systems may not capture the genuine organisational challenges faced when rolling out real systems. The scope of the TD-ABC model, as designed for this study, was developed to align with the research's objectives. Not all stakeholders of the case company participated in the model's development. As a result, the researcher preferred not to delve into factors or organisational challenges that could influence the success of the TD-ABC implementation.

Finally, this research examined the financial and operational data of transactions from Q1-2021 exclusively. While this dataset is sufficient for developing simulated TD-ABC and ABC models in line with the research objectives, a broader sample might offer deeper insights, given the potential for more comprehensive analyses. The researcher used Microsoft Excel spreadsheets to develop the model and analyse the three-month data. However, this tool is not the most efficient choice for processing larger datasets, especially when the quality of analysis is the top priority. The three-month data collected from the case company encompassed over 10,000 financial transactions. Thus, the choice of this tool and the duration of data collection were deliberate, ensuring that the research aims could be met without compromising the quality of outcomes.

1.8 Thesis structure

This thesis is structured into eight chapters. Following this introductory chapter, Chapter 2 reviews the supply chain management literature. Relevant topics such as developments in supply chain history, services, outsourcing, and the logistics company's model are discussed thoroughly. Next, Chapter 3 sheds light on the literature of the most common cost systems in management accounting. SC, ABC, and TD-ABC systems were reviewed in terms of history, design, advantages and disadvantages of each model separately. In addition, this chapter reviews similar studies discussing the TD-ABC system's role in logistics. Chapter 4 is devoted to the methodological approach followed in this research. The background of this approach, data collection methods, the selected case study, and the data analysis method are all discussed in this chapter. Chapter 5 discusses the case-study protocol. One of the validation methods in case-study research is to create a clear and detailed protocol for research procedures. The researcher followed this validation approach by dedicating one separate chapter to this goal. Future researchers can use this chapter as a guideline for TD-ABC development. Next, the researcher presents the results of the analysis in Chapter 6. This chapter has its structure explained in the introduction. Readers may need to read the appendix alongside this chapter, as most tables and figures are included. Chapter 7 is the discussion chapter, where the researcher reviews the research outcomes entirely, linking them back with what has been reported in the literature. Finally, Chapter 8, the concluding chapter, summarises the results of discussions in short points. Research contributions, limitations, and future research opportunities are all discussed in this chapter before closing.

Chapter 2 : Literature Review – Supply Chain Management

Introduction

The concept of logistics has been used for a very long time, even before it appeared in the business world. The military used this term as a name for the divisions responsible for the supply of food, weapons, and soldiers when they move from one point to another (Islam et al., 2013). In the business context, this term evolved in the 1950s (Ballou, 2007), and it refers to the movement and storage of goods, services, and information from the point of origin to the point of consumption. Therefore, adding the word management right after logistics refers to the effective management of that storage and movement. Logistics management, however, has many other terminologies that describe the same objective and deliver the same meaning. For example, business logistics management, integrated logistics management, and materials management are close terminologies that could be used as synonyms for the logistics management (Islam et al., 2013).

This chapter discusses logistics management in five sections, from different aspects. Section 2.1 explains how the logistics industry emerged and developed through different eras. Section 2.2 sheds light on the definitions of logistics management according to the professional body. Section 2.3 elaborates on the trend of outsourcing logistics activities to the different types of logistic providers, and Section 2.4 focuses on one type of those providers, which is fourth-party logistics (4PL). Finally, Section 2.5 shifts the discussion towards the cost management of logistics activities where it reviews some managerial techniques to control the costs in logistics companies.

2.1 The emergence and development of the logistics industry

Although logistics management has evolved remarkably over the last three decades, its basic principles were underpinned by the ancient people (Hugos, 2018). Logistics activities were practised many centuries ago to move the essentials such as food and medicines across continents. The ancient trade routes such as the Silk Road and the Spice Road provide some evidence of the profound existence of such practice (Sanyal, 2012). Since then, this practice has evolved dramatically and reached to boundless levels where we cannot easily predicate its ultimate future. The technological boom and some other factors have accelerated the pace of this evolution and redefined how it works. Jain J. K. et al. (2010) and Lavassani et al. (2008) identify six movements that were witnessed during the evolution of logistics management: the creation era, the integration era, the globalisation era, the specialisation era one, the specialisation era two and SCM2.0.

The creation era

In the 1980s, the term SCM was born as a reaction to the worldwide recession that severely hit global markets in the late 1980s and early 1990s. Companies initiated change programs that focused mainly on cost reduction and re-examination of the value creation models at the strategic level. Japanese managerial practices and initiatives such as lean management and just-in-time were adopted widely by the industry leaders to reduce costs and focus on the added-value processes. However, the goal of these treatment programs has shifted recently from merely cost reduction and adding value to the organisational processes towards customer fulfilment (Lavassani et al., 2008).

The integration era

The emergence of the second wave of the logistics evolvement started in the 1990s. Although the Electronic Data Interchange (EDI) system was first introduced in the 1960s, it has been more developed and adopted for logistics purposes since the 1990s (Lavassani et al., 2008). The role of this technology is to integrate the inter-organisational systems in a way that allows the users to exchange business information digitally. Therefore, it allows the members of any chain to plan, collaborate, forecast, and communicate effectively through this system. This role has definitely facilitated the flow of materials, information, finance, and all other resources along chains. Another aspect of integration is the ERP system, which was introduced in the same period, along with the EDI. ERP systems allow the internal players of a single organisation to exchange information digitally, and to align all internal departments together. Therefore, we can infer that while EDI systems are concerned with integration between the external parties, ERP systems are more concerned with the internal users. Both EDI and ERP systems have contributed to enhancing the efficiency of logistics management today (Lavassani et al., 2008).

Globalisation era

This era was influenced by the wave of trade globalisation, which resulted in the emergence of the global supply chain. The attention in this era was directed towards the "Supplier relations and the expansion of SCM over national boundaries and into other continents." (Lavassani et al., 2008). Companies in the late 1980s started to integrate global sources into their primary businesses. This trend has dramatically increased over the next few years, where one third of US trade was counted as parts and components produced outside the country (Lavassani et al., 2008). According to a report issued by McKinsey & Company: “by the year 2020, 80 percent of the goods in the world will be manufactured in a country different from where they are consumed compared with 20 percent now.” (Ballou, 2007, p. 341)

Specialisation era – phase one

This phase had started when companies started to outsource, partially or entirely, the production of their products to global manufacturers. The strategic objective behind this trend is to reduce costs, create more value, and enhance the competitive advantage (Jain J. K. et al., 2010). The availability of cheap labour at a reasonable-to-advanced level of competency in some developing countries encouraged tens of thousands of companies to utilise this opportunity. Consequently, logistics management had to adapt to this movement by improving its systems, processes, and practices to ensure better management for the global supply chain.

Specialisation era – phase two

In this phase, which started in the 1990s, companies focused on their core competencies and outsourced some of the not-core activities to strategic partners who could perform them more efficiently. New concepts in the SCM, such as logistics 3PLs and 4PLs, have emerged, and giant shipping firms such as FedEx and DHL have entered the market. As a result, companies have preferred to outsource logistics activities such as warehousing, order fulfilment, and distribution to those logistics service providers (LSP) who can accomplish better performance than the outsourcing companies when they run such activities in-house. Logistics has gone beyond transportation and warehousing and become defined as a service that associates with "supply planning, collaboration, execution, and performance management." (Jain J. K. et al., 2010).

SCM 2.0

In a similar way to what happened with Web 2.0, SCM 2.0 promises to improve the accessibility of resources needed for supply chain management ()Im & Kurnia, 2013(). Drawing a comparison to the rise of Web 2.0, Liu and Liu (2009) note that developments in technology have resulted in significant changes in processes, methods, and tools used in SCM. Online platforms have emerged as a means of bringing suppliers and customers together in one place, streamlining trade, shipping, finance, marketing, and other functions. This enhanced connectivity enables buyers to purchase goods from suppliers in different regions with greater ease, without concerns around quality, standards, finance, or logistics (Sutton-Brady & Spencer, 2022). Jain J. K. et al. (2010) posit that these platforms will foster greater collaboration and creativity in the SCM space, transforming it into a more information-sharing-oriented discipline.

2.2 Logistics management definition

In 1986, The Council of Logistics Management (CML) defined logistics management as “The process of planning, implementing, and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods, and related information flow from the point of origin to the point of consumption for the purpose of confirming to customer requirements." (Srivastava, 2008). This definition did not distinguish between logistics management and SCM as it implies that SCM is another meaning of logistics. Still, it's more about the chain, and this source of confusion in the definition is justifiable as it was proposed in the infancy of the SCM discipline. Therefore, CML modified this definition in 1998 to adapt to the new changes in this field. The new definition proposes that the logistics management is a part of the SCM process that is responsible for planning, implementing, and controlling "the efficient flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet consumers' requirements" (Fawcett, 2000, p. 370).

In 2004, CML changed its name to become CSCMP as a response to the new changes in the needs of its members and profession, according to Eilijah Ray who was the CML president in 2003-2004 (Staff), 2004). As a consequence, this leading-edge organisation has expanded its scope of interest and redefined the key definitions and boundaries of the SCM elements. The definition of logistics management, as a considerable part of the SCM, was amended again to become "that part of Supply Chain Management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customer requirements" (Rushton et al., 2022, p. 6). Considering the two-way direction of flow of goods, services, and information stated in this new definition, logistics management should not be limited to the downstream movement only. The up-stream flow, however, has been stated implicitly twice to emphasise the ultimate goal of any SCM, which is fulfilling the customers' needs and seeking their satisfaction. The up-stream movement of goods, services (reverse logistics), and information (e.g. feedback) from the point of consumption up to the point of origin is an indicator that logistics management is not only about cost and efficiency management as it was used to be, but it's also a competitive advantage source used by companies to acquire and maintain more customers (Mentzer et al., 2008).

2.3 The Outsource of Logistics Activities

Introduction

In the last few decades, outsourcing logistics activities to external providers has become a popular trend and source of attention of many managers. Companies have adopted this practice as a part of their strategy to compete and grow. To some organisations, logistics activities such as transportation, orders fulfilment, and warehousing, are considered supporting activities and not core ones. Therefore, decisions to offshore such activities are crucial for businesses to succeed in intense-competition environments. The focus on the main activities is a key towards success because the logistics services providers can perform more efficiently the supporting activities, which are considered their core business. As a response to this growing interest in outsourcing, the LSP market has evolved dramatically to meet customer satisfaction and to fulfil their changing expectations (Matopoulos & Papadopoulou, 2010). Historically, this market has passed three remarkable stages of evolution, according to (Berglund et al., 1999). The first stage was in the 1980s when the logistics companies provided basic services such as transportation and warehousing. The second stage started with the flourishing of express parcel delivery in the 1990s, which had been led by giant global logistics firms, e.g. FedEx. Finally, the information technology, management consultancy, and financial services provided by the LSPs have redefined this market and opened new doors for more opportunities for success for both outsourced and outsourcing firms.

Reasons to outsource

The decision to either outsource the logistics functions to logistics companies or to make them in-house is driven by many reasons. Damme and Amstel (1996) summarise and categorise these reasons into four considerations. First, economic considerations. The buy-or-make decision is investment-related. Logistics infrastructure investment can be a big sacrifice if there are other investment opportunities in different areas. The management needs to assess these opportunities and compare their cost and profit to the company strategy. The second category is market issues. According to (Damme & Amstel, 1996), there are two market issues that can affect the management decision to either use the logistics companies' services or not: demand fluctuations and commerce and flexibility. Some companies face seasonal fluctuations in their sales for a variety of reasons. In this case, the management may prefer not to invest in the logistics function and, instead, contract out these activities to an LSP. On the other hand, commerce and flexibility play an essential role in some companies that prefer to engage and support their customers directly. Thirdly, the availability of personnel and equipment is a critical determinant of who should manage the logistics activities. Some companies prefer to eliminate wasted time and effort in hiring and training people in the logistics area. Therefore, they tend to buy the logistics services, instead. On the other hand, others may prefer to control all processes in their businesses including the logistics functions, so the decision will be taken to implement the logistics activities internally. Finally, the dependence is an influential factor in this context. The desire to react rapidly to any logistics-related matter such as checking and stocktaking inventory can make companies favour of the in-house logistics management rather than the contracted out.

The logistics company selection decision

For companies that elect the outsourcing strategy, selecting the right logistics company that fits the company's needs is not an easy task as it involves a high level of uncertainty. Therefore, this selection must pass through multiple decision-making processes starting from pointing out the available alternatives and ending with the assessment of the chosen supplier's performance. Sink and Langley (1997) have developed a managerial framework that helps companies to make informed decisions in this regard. The framework suggests five steps that lead to not only finding the right logistics partner, but to also maintaining a successful relationship in the long term. These steps are:

1- Identify the need to outsource.
2- Develop feasible alternatives.
3- Evaluate and select supplier (including criteria development).
4- Implement service.
5- Ongoing service assessment.

Interestingly, the researchers state that although these five stages are scientifically developed, the decision to select the best candidate is heavily dependent on three factors: analysis, bargaining, and judgement. Among these factors, judgement is the most important criterion for reaching the final decision and hiring the best candidate (Sink & Langley, 1997).

The logistics company selection, as mentioned previously, is a complicated process. A number of academics and researchers have contributed and discussed issues that relate to this concern over the last decades. As a result, many mathematical models and heuristic methods have been proposed in the SCM literature to examine predefined criteria that must be considered when making such decision (Govindan et al., 2016). Examples of these models and methods can be found in studies, such as (Haldar et al., 2017) which developed an integrated method involving data envelopment analysis and linear programming to select the right logistics provider (Daim et al., 2013; Gürcan et al., 2016) which use the analytic hierarchy process approach, and (Pamucar et al., 2019) that proposes a new integrated interval rough number based on multiple approaches to assess the logistics providers.

In addition to the LSP-selection models and methods, there is also a need for models that can help outsourcing companies to evaluate their decision on an ongoing basis. One of the most common models in the SCM that can help assessing the logistics partners is the Supply Chain Operations Reference (SCOR) model, which was developed by the Supply Chain Council in 1996. This model proposes performance measurements for the supply chain members, including the LSP, based on four criteria: supply chain reliability, responsiveness/flexibility, costs, and assets (Lai et al., 2002). Agility has been added as a fifth criterion in a recent update. These performance criteria can measure the LSP's efficiency in operational areas such as delivery time, perfect order fulfilment, and supply chain response time. Such metrics are powerful in evaluating the LSP's performance and making sound decisions in this regard.

The mathematical models proposed above can't run without predefined criteria. To make a sound LSP-selection decision, the management needs to embed many factors into the proposed model in order to comprehensively evaluate the available alternatives. Qureshi and Kumar (2008) developed an integrated model based on interpretive structural modelling and FMICMAC analysis to identify and classify the key criteria that should be considered when partnering with an LSP. The findings of this analysis reveal that the quality of service, sharing information and trust, operational performance, geographical spread, range of services, delivery performance, financial stability, surge capacity, and optimum cost are strong criteria that have strong power on the selection decision. Sink and Langley (1997) have a shorter list of criteria and they state that quality, cost, capacity and delivery capability are enough to run the models when evaluating LSPs. Fitzgerald (2007) recommends considering other intangible criteria that could play a critical role in the success of the partnership with LSPs. Factors such as cultural alignment and partnership intangibles (e.g. global collaboration) are as important criteria as the other common ones such as IT capabilities and company infrastructure.

The LSP's performance

This literature review draws upon various studies to explore the growing trend of outsourcing logistics functions to LSPs. As noted by Christopher (1999), this trend has created significant opportunities for logistics companies. However, the pressure to serve partners at high levels of performance and lower cost has presented a real challenge for LSPs. Lemoine and Dagnæs (2003) examined the impact of globalisation on logistics service providers (LSPs) and their business organisation strategies. The authors contend that the logistics industry is characterised by tight margins, further exacerbating this pressure. In response, LSPs are increasingly looking for ways to increase profitability through value-added services. However, such decisions require careful attention and control from management to ensure competitiveness and profitability. As the need for LSPs became established in the literature, many authors highlighted the need for and importance of performance measurement frameworks of LSPs.

Jothimani and Sarmah (2014) focused on the performance measurement of the 3PLs in the supply chain. The authors highlight the importance of measuring the performance of 3PL providers to improve the efficiency and effectiveness of the supply chain. LSPs must establish tools for measuring key performance indicators (KPI) to monitor operational and financial performance consistently. Varadejsatitwong et al. (2021) found that such performance measurement frameworks enable companies to assess the extent of success and predict the likelihood of failure, enabling corrective actions to be taken in a timely manner.

To comprehensively evaluate the LSP performance, researchers proposed an evaluation that includes a reasonable range of financial and operational indicators from both quantitative and qualitative metrics. Data that reflect cost, profitability, time, faults, customer base growth, and assets utilisations are labelled as quantitative metrics, and they're not enough to assess the overall performance (Lee et al., 2012). The literature stresses the need for more metrics from qualitative data such as environmental factors, customer perception, and employee happiness (Lambert & Burduroglu, 2000; Oberhofer & Dieplinger, 2014; Yeung, 2006). According to Krauth et al. (2005), the latter group is less covered in literature as more focus is dedicated to the quantitative metric.

The management consulting firm PRTM (now part of PwC) in collaboration with the Supply Chain Council proposed the Supply Chain Operations Reference (SCOR) model in 1996. The SCOR model is a framework for analysing and improving the performance of supply chain operations by providing a common language, metrics, and best practices for supply chain management (Stewart, 1997). It has become a widely used standard in the industry and has been updated and expanded over the years to reflect changes in the global supply chain landscape (Ayyildiz & Taskin Gumus, 2021; Kocaoğlu et al., 2013; Min & Jong Joo, 2006). Another measure that is widely used in SCM is Balanced Score Card (BSC). Kaplan and Norton (1996) proposed BSC in 1996. Since then, the concept has gained widespread popularity and has been used by many organisations as a strategic management tool.

Tools like SCOR and Balance Scorecard are useful to measure performance in both qualitative and quantitative manners. The SCOR model, for example, contains 250 metrics that measure two main categories: efficiency (internal-facing) and effectiveness (customer-facing) (Delipinar & Kocaoglu, 2016; Dissanayake & Cross, 2018). The efficiency category consists of tens of measures that concern the internal performance aspects such as revenue and cost while the effectiveness category is more concerned with the external parties (e.g. customers) as it measures related aspects such as delivery time and perfect order fulfilment (Lai et al., 2002).

Challenges

3PL providers are faced with a multitude of challenges in their daily operations. Researchers have investigated these challenges to gain insights into the issues that 3PLs face and to provide guidance on improving their operations. A number of studies have been conducted to identify and analyse these challenges, which include issues such as customer demands, talent management, and technology investment (Gabriel & Parthiban, 2020; Ho et al., 2018). Lieb and Bentz (2005) conducted a survey of 25 CEOs of the major LSPs in North America to gain insights into the logistics market opportunities and challenges. The executives identified several issues, with three significant problems emerging as the most pressing: first, strong downward pressure on prices by customers, resulting in lower margins and potential losses from customers undervaluing the true cost of 3PL services; second, the difficulty in finding, training, and retaining skilled employees who can adapt to the complex and dynamic logistics environment; and last, the high IT investment costs with low returns due to the resources required to integrate customer and 3PL systems, despite customers not understanding the associated costs.

Gabriel and Parthiban (2020) synthesised the existing academic literature on this topic and identified several key challenges faced by 3PLs, including the need to manage customer expectations, the increasing complexity of supply chains, and the importance of adopting new technologies. The authors also discussed the importance of collaboration between 3PLs and their customers, as well as the need for 3PLs to continuously monitor and improve their operations in order to remain competitive. Overall, the article provides a comprehensive overview of the challenges faced by 3PLs in the global logistics industry.

Types of LSPs

In the logistics industry, the customers' needs and requirements have been increasing dramatically over time due the new developments in technology and the impact of other factors such as globalisation. Thus, the counterpart LSPs must correspond and provide sophisticated operational, tactical, and strategic solutions to meet those needs. According to (Collin & Eloranta, 2009; Fisher, 1997) the supply of services provided by LSPs is defined by the customers' demand. Consequently, the LSPs models and types should be designed and adjusted to be well-suited with the services-categorisation framework (Soinio et al., 2012). Over time, the forms and types of LSPs have evolved to adapt to the industry's developments. The basic types of LSPs such as carriers and freight forwarders are not enough to satisfy the customers' high expectations. New forms such as 3PLs, 4PLs, and 5PLs have emerged recently to go beyond the traditional logistics services concentrated in transportation and warehousing and to provide more added-value services such as planning and forecasting.

3PLs

This type of LSP is the most widely used logistical partner in the contemporary economical era (Hickson et al., 2008). The trend towards outsourcing the basic logistical activities (e.g. warehousing and transportation) to LSPs is not recent; it started in the 1950s. However, when companies began to focus on the supply chain optimisation, by the 1980s the 3PL model emerged to provide those companies with more sophisticated logistics services at higher levels of competency and lower cost (Farahani et al., 2011). 3PLs provide a wide range of services to their customers including, but not limited to, planning, inventory control, reverse logistics, orders fulfilment, and light maintenance and repair.

4PLs

Rapid market shifts, increased variation in consumer demand, advances in technology, and expanded organisational solutions need partnerships with innovative logistics service providers (Hanus, 2013). These evolutions gave rise to 4PL. The progression from 3PL to 4PL involved a shift from outsourcing specific logistics functions to outsourcing entire supply chain management. 4PLs act as strategic partners, managing multiple logistics providers and integrating various supply chain components for greater efficiency and visibility. With their cutting-edge approaches to logistics, 4PL companies are quickly rising to the top of the global logistics industry (Pavlić Skender et al., 2017).

In contrast to a 3PL, which may be more transactional in nature, the main benefit of a 4PL partnership is that it is a strategic engagement focused on offering comprehensive services to achieve results across the entire supply chain. Shmatko et al. (2021) contend 4PL acts as an organisation's central logistics hub. Even when using a third-party logistics provider, numerous facets must still be managed by the business itself. According to (Gencer, 2019), 4PL assumes responsibility for all activities and functions throughout the supply chain, including coordinating with 3PLs, warehouse providers, and other stakeholders.

Like 3PL, 4PL coordinates the activities of various businesses involved in the downstream supply chain. It offers a comprehensive service where it manages all the flows across the supply chain. In most cases, these businesses are 3PL providers that have expanded their offerings to include these capabilities or partner with other organisations. Fourth-party logistics providers take logistics partnerships to a new level by increasing the integration and engagement of all the supply chain partners and activities involved (Ciemcoich 2018).

5PLs

The future of SCM can be seen through 5PLs. This most recent type of logistical partner is distinguished from others by its unique business model that employs technology in the SCM. Although the concept of 5PLs is still emerging in the literature, Sundarakani et al. (2012) state that this innovative type of LSPs is regarded as a virtual entity that has no physical presence, but it has the ability to manage the entire supply chain at a strategic level. With no tangible assets, this type of company utilises advancements in technology to provide web-based services to the participants in the supply chain. Examples of such innovative services are real-time visibility over the supply of materials at any point in the chain, the control of the supply chain in e-businesses, and virtual coordination among the chain members.

2.4 4PLs logistics

The 4PL idea illustrates a trend toward the next level of outsourcing, where the service providers manage the entire supply chain. Despite the fact that this phenomenon has been the topic of study in academia for a long time, however, it is still only a notion. The idea was first presented by Accenture in 1996, who defined a 4PL service provider as "an integrator that assembles the resources, capabilities and technology of its own organisation and other organisations, to design, build and run comprehensive logistics network solutions." (Pinna & Carrus, 2012, p. 105). LSPs and their advanced level services have been categorised in a hierarchy in literature where each progressive level provides more comprehensive logistics services than the previous level. Figure 2-1 shows the successive order of various service providers and the span of their services.

Relationship and Pricing Model	Service Offerings	Logistics Outsourcing	Key Attributes
Partnership Value Based	Advanced Services	Forth-Party Logistics Provider (4PL)	- Strategic relationship - Broad supply chain expertise - Share risk and rewards - Advanced technology capability - Adaptive, flexible, collaborative
Contractual Risk Sharing	Load Logistics	Lead Logistics Provider (LLP)	- Project management/contract - Single point of contact - 3PL technology integration
Contractual Fixed & Variable	Value Added	Third-Party Logistics Provider (3PL)	- Enhanced capabilities - Broader service offerings
Commodity Transactions	Basic Services	Logistics Service Provider	- Focused cost reduction - Niche services

Figure 2-1:Key attributes of logistics outsourcing providers (Pavlić Skender, Mirković & Prudky 2017, p. 99)

4PL is a more sophisticated and advanced form of supply chain service and is essentially different from its predecessor in the context that it optimises the entire supply chain. In contrast, 3PL focuses only on the part of the supply chain related to fulfilment, including warehousing and shipment. Recent studies have shown that it has tremendous potential, which, if realised, might result in an improved competitive position in the modern business environment. This provides businesses with a convincing argument to reassess their logistics outsourcing strategies and make other necessary changes to their supply chains (Pavlić Skender et al., 2017). Since the rise of logistics service providers has had a tremendous impact on the global economy, business owners, analysts, managers, and researchers must be familiar with the characteristics, potential, and risks presented by 4PLs. 4PLs have the potential to improve a company's ability to manage the complexities of today's dynamic business by effectively mobilising resources (Govindan et al., 2016).

The 4PLs logistics activities

The logistics activities compose one of the critical elements of any SCM. These activities are not only bounded to the process of logistics as a functional area in a given company, but they're also extended to all other areas within a firm to implement all eight critical processes of the SCM defined by the Global Supply Chain Forum (Maria et al., 2016). In terms of the logistics activities that fall within the logistics area as a function, Mentzer et al. (2008) define the main logistics activities as: transportation management, warehousing management, material handling management, system-wide inventory management, order fulfilment and order management, procurement, and customer service. Other researchers either simplify these activities, such as (Islam et al., 2013), who summarise these activities into only five main activities, while others expand the boundaries to include more, such as (Coyle et al., 2013), who includes more than ten main activities.

On the other hand, the logistics activities that are implemented outside the logistics area are enormous and powerful to any SCM. Maria et al. (2016) propose a comprehensive framework for the logistics activities under each supply chain business process suggested by the GSCF model. Furthermore, the researchers provide a conceptual framework that explains how these activities should be implemented. For example, since the eight supply chain business processes suggested by the GSCF model start with customer relationship management, the logistics information can be used to analyse the customer profitability and to segment the customer based on multiple factors. Similarly, supplier relationship management, as a second supply chain business process, can benefit from the logistics activities that provide valuable information about the cost of ownership of purchased materials or products. Interestingly, the integration between the logistics activities and the supply chain business processes can go beyond these two examples and provide tremendous value to all eight functions.

Warehousing management

Warehousing is a crucial activity and an essential element of any supply chain. Receiving, putting away, storing, picking, and dispatching goods are the most common and primary activities that fall under this category. Warehousing management is strongly interrelated to other logistics activities, such as inventory management and order fulfilment. The logistics management literature is rich in studies that discuss topics related to this activity, such as the warehousing design (Baker & Canessa, 2009; Faber et al., 2013; Kembro et al., 2018; Rouwenhorst et al., 2000) warehousing operation and performance (Gu et al., 2007; Krauth et al., 2005; Staudt et al., 2015) and other topics such as centralisation versus decentralisation in warehouses (Pedersen et al., 2012). Recently, researchers have paid more attention to the profound and rapid changes that have affected this activity due to technological developments and changes in consumer behaviour. For example, people have become more reliant on electronic commerce. Consequently, new trends such as small orders, large assortments, tight delivery schedules, and varying workloads that associate with online shopping preferences, have emerged and affected conventional warehousing management, which has become unable to meet these challenges (Boysen et al., 2019).

Transportation management

Transportation is a critical part of logistics management, and it is responsible for moving goods from one point to another. The current status of transportation is a result of a gradual evolution since ancient times when people needed to move their goods and change their locations. However, the acceleration rate of this evolution has risen over the last century. At the beginning of the 1900s, trains and planes were just invented. In 1956, a new way of transportation was discovered: maritime transportation (Grazia, 2018; Speranza, 2018). Since then, the shape of trade has changed dramatically, which has opened new doors for researchers to discover the issues concerning this crucial activity. The infrastructure, transport mode options, modal transfer points, load planning, and routing and scheduling are vital aspects that always need an efficient management (Islam et al., 2013). According to Tseng et al. (2005), a well-managed and developed transport system is the secret key to successful logistics management. In other words, logistics can't provide full benefits without a well-developed transportation system.

Inventory control

Inventory control (or management) is another key to efficient supply chain management. It’s a source of customer satisfaction as it aims to meet their demands with the proper supply at the right time. To many, this activity is another name for warehousing management or one of its activities. However, inventory control differs from warehousing management and consists of multiple activities that differ from warehousing management activities. Wild (2017) claims that inventory control is more about managing the availability of items to meet marketing needs. This involves maintaining the appropriate stock levels, forecasting demand, monitoring and controlling service and inventory, organising deliveries, etc. In addition, it involves the coordination between the other functions associated with supply, such as purchasing, manufacturing, and distribution. On the other hand, Wild (2017) argues that the physical control of inventory, such as receiving items, orders fulfilment, and dispatching, do not fall under inventory management activities. They're different disciplines. He categorises these physical activities under warehousing management. In short, the difference between inventory management and warehousing management lies in their role. Inventory management aims to maintain the stock at the right level and condition, whereas warehousing management aims to implement the physical movement of this stock.

Order fulfilment

In today's business era, the customer's satisfaction is determined mainly by how he found the experience of placing an order from a specific company. The speed of order processing, packing, and dispatching is the hidden secret behind many businesses' success, especially those in the e-commerce industry. Behind the scenes, such company logistics departments work hard to meet their customers' expectations by implementing several activities to fulfil their orders rapidly and efficiently at a lower rate of mistakes. Croxton et al. (2001) consider order fulfilment as one of the eight key business processes of SCM. In a later study, Croxton (2003) elaborates on how this process should work in organisations. As a primary activity of logistics management, order fulfilment involves tens of sub-activities and tasks that start from generating or receiving orders, checking inventories, picking and packing, preparing shipping documents, and dispatching, and that end with receiving payments and measuring the process performance. Although many view this activity as an operational part of the logistics function within a firm, it's important to recognise it as an essential pillar of any SCM, and it plays a strategic role in determining the success of the entire chain.

Material handling

Stephen and Meyers (2019, p. 209) defines material handling as "the function of moving the right material to the right place, at the right time, in the right amount, in sequence, and in the right position or condition to minimise the production costs." The American Society of Mechanical Engineers goes beyond this definition and considers this activity as a combination of art and science that involves moving, packaging, and storing materials in any form. According to (Stephen & Meyers, 2019), this activity has five unique dimensions: time, quality, movement, space, and control. For example, the time aspect could affect the work in process, excessive inventories, and the lead time of order delivery. On the other hand, space is a critical determinant of the storage available for material handling equipment and the movement inside the facilities. As with any other firm activity, material handling aims to accomplish several goals. The primary goal of this activity is to reduce the final cost of products and services by adopting the best practices and following rigid principles.

Freight forwarding

Freight forwarding is an activity associated mainly with exporting and importing goods across borders (Rudd, 2019). The process of this activity may vary from one location to another depending on the regulations and rules imposed by countries, and it can't be implemented by manufacturing or trading companies in most cases. However, there is a type of independent LSP called freight forwarders who can handle this process from receiving goods from the shipper's warehouses to the last-mile delivery.

Customs clearing

This activity is interrelated with the previous activity, freight forwarding. When shipments arrive at seaports, airports, or even border checkpoints for import or export, local customs require the shippers and receivers to clear their shipments through customs brokers. The customs brokers are individuals or companies who have permission from the local customs to practise this activity after they demonstrate a certain level of knowledge in export and import regulations, procedures, tariffs and other taxes or fees imposed (Rudd, 2019). This activity requires document preparation and coordination with the freight forwarding companies to ensure a smooth flow of shipments.

Customer service

The ultimate goal of any organisation, except not-for-profit organisations, is to maximise profit. This justified goal can't be achieved without satisfied and loyal customers. Therefore, providing superior customer service is one of the most critical success elements for any logistics function or company. Christopher (2016) claims that customers can prefer businesses over their competitors through better management of logistics and supply chains. In other words, the efficient logistics and supply chain and the excellent customer support provided by logistics functions and companies lead to a higher rate of satisfaction and preferences, ultimately leading to higher profitability. According to (Matuszczak & Chrąchol-Barczyk, 2016), the logistics customer service process consists of three stages: pre-trade, trading, and post-trade. Clarity of written policies and customer service flexibility are examples of pre-trade logistics customer services. On the other hand, the time needed to accept new orders and the quality of packaging are common indicators of the high quality of customer service in the second stage, trading. Finally, the availability of order tracking and the ease of handling claims, returns, and complaints are examples of excellent customer service after the trade (Matuszczak & Chrąchol-Barczyk, 2016).

Demand planning

Demand planning service aims to maintain equilibrium in a supply chain between supply and demand. According to (Jüttner et al., 2007), effective demand planning seeks to offer more excellent value through rigorous analysis of market needs, potential advantages, and necessary supply capabilities. Demand planning has primarily been based on forecasting previous sales and market data. In the literature, various qualitative and quantitative methods are available to forecast demand. In quantitative methods, many researchers implemented causal models to forecast the demand based on certain factors (Geurts & Patrick Kelly, 1986; Ryu & Sanchez, 2003), while others have implemented time-series models that predict the demand by analysing the historical data (Cranage & Andrew, 1992; Mentzer & Moon, 2004). Qualitative methods rely on experts' knowledge to predict the demand. There has been an increased use of machine learning and artificial intelligence in accurately forecasting demand, for effective demand planning (Moroff & Sardesai, 2019).

Procurement

The term procurement refers to the process of acquiring goods and services from external sources. It can be used interchangeably with other terms such as purchasing, supply management, buying, and contract management. This process should be managed as part of the SCM and connected to the integrated supply chain (Gattorna, 2010). The Chartered Institute of Procurement and Supply in Australasia (CIPS Australasia) defines this function as "the business management function that ensures identification, sourcing, access and management of the external resources that an organisation needs or may need to fulfil its strategic objectives." (CIPS Australaisa, 2013, p. 3). Accordingly, procurement doesn't only cover the activities that occur before purchasing items from suppliers but also those that occur after receiving the purchased items. Reviewing the suppliers' performance and contract management are two examples of post-contract activities. In today's businesses, procurement goals exceed profitability enhancement and cost reduction. Rather, efficient procurement management should also support innovation, reduce risks, improve quality, and increase efficiency (Kidd, 2005).

Reverse logistics

As producers, wholesalers, distributors, and retailers implement tens of logistics activities to pass down their goods and services to consumers, there is also a need to find a way that reverses the flow of these products and services from the point of consumption to the point of origin. In SCM, this activity is called reverse logistics, and it's an essential element of the logistics framework as it deals with activities such as returns management, recycling, and remanufacturing. Since the early 1980s, researchers have proposed several definitions for reverse logistics in attempts to define its activities scope, size, and all other related concerns (Rogers & Tibben-Lembke, 2001). Rogers and Tibben-Lembke (2001, p. 130) define reverse logistics as "the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing or creating value or proper disposal."

Other value-added services

As the business environment evolves and the competition gets more intense, the need for new logistics services also increases. The logistics departments within businesses and the logistics companies provide tens of other value-added services to their customers. Labelling, product registration, quality assurance, light maintenance, and product localisation are a few examples of such value-added services. The noticeable orientation towards outsourcing logistics functions to logistics services providers has allowed the range of these services to expand to meet the customers' demand (Soinio et al., 2012) and to increase profitability by adding new revenue streams (Lemoine & Dagnæs, 2003).

2.5 The logistics cost management

As the supply chains became increasingly global and complex, the need for more sophisticated logistics cost management systems grew. The development of advanced technology and software such as enterprise resource planning (ERP) systems, has allowed companies to better track and manage their supply chains, leading to greater efficiency and cost savings. Silva et al. (2014) contend that today, logistics cost management is an essential part of most businesses, as they seek to optimise their supply chain operations and stay competitive in an increasingly global and fast-paced marketplace. Companies employ a variety of strategies and techniques to manage logistics costs, including outsourcing, inventory management, transportation optimisation, and supply chain visibility. Logistics cost management is the process of controlling and minimising the costs associated with the movement of goods and materials through a supply chain. It involves identifying the different components of logistics costs, analysing them, and implementing strategies to reduce or optimise them (Seuring & Goldbach, 2002).

According to Yan (2019), cost management is considered the third source of profit after the cost reduction of production and the increases in the sales volume in the logistics industry. Due to the increase in the number of logistics activities and the high customer-satisfaction standards, the logistics costs have been increasing and thus need to be wisely managed. Silva et al. (2014) stress the need of adopting a scientific costing method has become a necessity in order to achieve a high level of transparency in the cost of responsibility centres. In logistics firms, most responsibility centres are labelled as cost centres. Xiao et al. (2009) found that by effectively adopting innovative strategic cost management tools and techniques such as cost-to-serve, value-chain management, and target costing, LSPs will be able to monitor their financial performance clearly and achieve their strategic objectives.

ABM

As discussed in the preceding chapter, the ABM is an innovative managerial tool that helps managers to back their decisions with solid and insightful data generated from the company's information system about the business activities, processes, budget, resources, and more. It's the wide version of the ABC and TD-ABC system, which, on the other hand, concentrates mainly on calculating the cost of products and services. Baker (1998) identifies the scope of the ABM systems in three elements: activity analysis, cost driver analysis, and performance analysis. The adoption of such an innovative system by logistics companies' management will enable them to obtain more accurate cost and performance targets, reduce waste in activities by focusing on the added-value ones, and improve the quality of pricing as the managers will be able to read more accurate information about the cost of products and services.

Miller (1996) defines a set of specific and general uses and benefits for ABM. First, companies can use ABM to determine product/service costs as they find ABC and TD-ABC systems are accurate sources of cost information. Second, ABM can improve the performance of processes and activities. Since ABM's concept focuses on activities as the heart of operations, implementing an ABM-based system allows for more visibility of the activities performed. Accordingly, management can make informed decisions to improve such processes. Third, ABM is necessary to evaluate the business' current expenditure-activities relation. During economic downtimes, companies tend to cut costs as a reaction. ABM is an analytical tool to evaluate resources that need to be maintained versus those that can be eliminated. "The only truly effective way to cut costs is to cut out activities altogether." (Miller, 1996, p. 18). Other applications can be found beneficial for companies, such as using ABM for outsourcing evaluation, strategy development, project management, budget construction, and setting cost targets (Miller, 1996).

Cost-to-serve (CTS) technique

Van Niekerk & Bean (2019) stressed the need to adopt powerful tools such as the CTS technique to evaluate the feasibility of the demand-and-supply relationship in today's business world. The authors highlight the need for companies to understand the cost of serving customers in a market where customers have the power to influence how products and services are designed and provided in small-lot deliveries. Guerreiro & Merschmann (2008) provided background on how businesses used to operate in the past and how customers had to accept what the market supplied. However, the present business environment is characterised by intense competition, and customers have more power to guide the market. The authors suggest that companies need to know how much the demand-and-supply relationship costs, and that not all customers are profitable. To address this challenge, many researchers recommend the use of the CTS technique, which is a powerful application of the ABC/ABM systems (Guerreiro & Merschmann, 2008; Holcomb et al., 2014). The ABC/ABM systems provide detailed information about customer service costs, enabling companies to determine the cost of customer service accurately. Holcomb et al. (2014) suggest that without a sophisticated costing tool, such as the CTS technique, it would be impossible to determine the cost of customer service.

Kamphuis (2020) developed a framework to help fast-moving consumer goods (FMCG) companies visualise the output of a cost-to-serve analysis. The author argues that FMCG companies often struggle to gain insights into their cost-to-serve and how it affects their profitability. The framework proposed by Kamphuis consists of several steps, including identifying the scope of the analysis, mapping the current supply chain, determining the cost drivers, calculating the cost-to-serve for each customer and product, and visualising the results. However, CTS is different in the case of LSPs as they operate complex processes for tens of clients with thousands (or even more) of customers. Control over this huge operation environment is essential. Customers vary in their behaviour, and some behaviour is costly. Last-minute changes, misleading information, and not-well-packaged items are costly. They should be captured by the costing system to calculate the cost-to-serve per customer correctly. Pieterse (2011) highlighted the importance of developing customised route-to-consumer strategies to improve service levels to different customer channels while also being cost-effective. The author highlights the need for companies to understand the unique characteristics of each customer channel, including their buying behaviours, preferences, and service expectations, to tailor their distribution strategies and to factor in the CTC accordingly.

Customer profitability analysis (CPA)

CPA, or sometimes called customer account profitability (CAP), is another advanced management accounting tool that can improve LSP financial performance. Van Raaij (2005) describes the CPA as allocating revenue and costs to the customer segments and/or individual customer accounts. The core purpose of this tool is to help management make strategic decisions to increase income by evaluating the cost-and-benefit relationship with customers. It differs from the CTS technique as it includes the revenue in its scope, where customer profitability may derive from variations in revenue, cost, or both sources.

According to (Gupta et al., 1997), variations in revenue arise from different factors, including sales prices, volume, and discounts. On the other hand, the cost differences are derived from a broad range of drivers, such as the level of support the customers need when they buy products or services. In addition, the hidden costs may result in unprofitable relationships with customers if the company fails to detect and resolve them. For example, the credit or delivery terms for specific individuals or groups of customers can be a source of loss if they're not aligning well with the level of resource consumption. In this case, the management may impose stricter terms to avoid losses or even more, terminate the relationship with the losing customers. The CPA, in such examples, is a powerful tool that can help detect losses early and increase revenue streams.

While CPA may seem similar to the product profitability analysis (PPA) in terms of their goals (offering valuable insights about profitability), the CPA is more important than the PPA, at least in the service-based industries such as logistics (Anderson & Kaplan, 2007). The CPA offers insights about the profitability of individual customers as well as segments of customers while the PPA offers more about the products and services' profitability drivers (Smith & Dikolli, 1995). In the logistics sector, the CPA takes precedence as the nature of this industry requires high levels of service quality and relationship management to satisfy customers (Gaudenzi et al., 2020). The various customers that may represent different industries with different demands, contract terms, service levels, locations, and more variables constitute challenges to the LSPs to understand the profitability of each customer relationship (Helgesen, 2007).

Process efficiency plays a crucial role in enhancing profitability, as stated by Muthimi and Mwarora (2023) when they proved the significant influence of business process re-engineering on performance metrics including profitability. Efficient process leads to numerous benefits such as waste elimination, error minimisation, and expedite deliveries, which will eventually lead to cost savings and customer satisfaction (Qin & Liu, 2022). In the CPA context, understanding the process that drive customers' costs can lead to better management and allocation of resources (Rosinosky et al., 2018). For example, when a particular customer demands extensive administrative support or more frequent deliveries, the management can investigate the associated process to find better way of implementing these services aiming to reduce the cost of operations or, at least, to ensure fair pricing (Anderson & Narus, 1998).

AYRANCI and Gizem (2022) found significant correlation between stock management and profitability in businesses. Holding excessive stock leads to higher costs associated to inventory management and tied capital, while shortages in stock may lead to loosing sales opportunities and unsatisfied customers (Cooper & Kaplan, 1991). By integrating CPA with inventory management, companies can have better understanding about the ideal stock level for the their most profitable customers without incurring unnecessary costs. Rosic (2012) claims that the effective supply chain management ensures the right products are produced and distributed in the right quantity to the right locations in the right time. This balance between efficiency and responsiveness is crucial to minimise costs while satisfying the profitable customers (Rosic, 2012).

The CPA becomes more complex yet invaluable when it comes to serving one customer with multiple outlets. Each outlet will have distinct operational characteristics, purchasing behaviours, and service requirements (Smith & Dikolli, 1995). For example, one outlet might order in bulk but less frequently than others, which will result in different resource allocations when serving this outlet. Accordingly, the profitability among outlets will vary depending on the cost structure and resource allocation. By applying the CPA at the individual outlet level, LSPs can gain deeper insights into the profitability landscape, which will enable them to make informed decisions about services, pricing, and resource allocation to each specific outlet (Helgesen, 2007). Furthermore, such granular data will positively impact the long-term relationship with clients as LSPs can provide tailored solutions and recommendations that serve the unique needs of each outlet, leading the overall profitability and customer satisfaction (Shank & Govindarajan, 1993).

Balanced Scorecard

In the age of technology and global competition, companies must adopt a balanced strategy to ensure high financial and operational performance, continuous innovation, and sustainable growth. The traditional strategy systems and performance indicators that were effective in the industrial age and focused on the financial measures alone are inadequate in this new era, driven by the rapid changes in technology and innovations. Organisations today have to set outstanding performance measures for both the internal and external aspects of the business and ensure a comprehensive monitoring system is in place. In 1992, Kaplan and Norton developed the Balanced Scorecard (BSC), a new strategy system that looks at the business from four different angles: financial perspective, internal business perspective, customers perspective, and learning and innovation perspective (Rajesh et al., 2012). Including these four perspectives lets management simultaneously observe the most critical aspects of the business. LSPs can utilise this tool to monitor their complex operations and link them to the strategic vision and goals at both corporate and department levels. Each department of the LSPs can set its individual BSC system that suits its activities nature and helps to reach its own and overall goals.

According to (Rajesh et al., 2012), to design a robust BSC system in organisations in general, and in an LSP specifically, there are two recommended steps to follow: defining the organisation's vision, mission, and strategy and translating the strategy into operational terms and developing performance measures and goals. By implementing these steps on an LSP case company in India, (Rajesh et al., 2012) have developed a BSC system for each department in that company, with a focus on the warehousing department as the main function, as well as a general BSC system for the corporate management level. For the warehousing department's system, the researchers have identified several strategic objectives, measures, and targets from the four aforementioned business perspectives (Figure 2-2). Similar systems can be designed in more detail for any LSP to achieve multiple goals ranging from cost reduction, on-time delivery, capacity utilisation, layout optimisation, customer satisfaction, skilled teams, advanced technology, and revenue growth.

Perspective	Strategic objective	Measure	Calculation	Target
Financial	F1: Reduce average warehouse/storage cost per order	Cost per order(min)	Total warehouse cost/total orders shipped	5%
Customer	C1: Develop strategy for warehouse operations	On-time delivery	Orders on-time/total orders shipped	99%
	C2: Improve warehouse utilization	Storage utilization	Avg. occupied Sq. m./total storage capacity	90%
	C3: Provide accurate billing statement for storage	Dock to stock time (min)	Total dock to stock hrs./total receipts	30 min
Internal process	P1: Enhance warehouse order processing	Order fill rate	Orders filled complete/total orders shipped	98%
		Order cycle time	Actual ship date – customer order date	1–30 h
		Perfect order completion	Perfect deliveries/total orders shipped	100%
	P2: Eradicate errors in storage and picking	Order accuracy	Error-free orders/total orders shipped	99%
		Damaged inventory	Total damage/inventory value	0.3%
Learning and growth	L1: Develop employee relationship for better work environment in stores	Items per hour	Items picked or packed/total warehouse labor hrs.	100 items per hour
	L2: Create and contribute on warehouse related content	Money invested in employee training yearly		

Figure 2-2: The BSC system for a logistics company according to (Rajesh et al., 2012).

Bhagwat and Sharma (2007) claim that companies must better understand SCM-related tasks to achieve success when aiming to develop an efficient BSC. This knowledge helps to correctly measure and show work processes, which is a primary goal of BSC in looking to link daily work with larger organisational objectives (Peris-Ortiz et al., 2019). By gaining familiarity with specific tasks and the corresponding time spent, organisations can also pinpoint and fix any issues and thus work more efficiently and productively as a unit (Huynh et al., 2020). Dedicated methods such as TD-ABC can help in this regard by more closely examining work processes, highlighting the BSC as an effective way to assess both financial and operational performance on a side-by-side basis (Marzuki et al., 2020). Therefore, understanding tasks and the associated time investment helps the BSC shine through as a preferred tool for boosting work performance and achieving goals in various types of organisations.

Time plays a significant role in the scorecard framework, influencing how activities are carried out and monitored. Kaplan and Norton (1996) thus implore organisations to align their activities with term plans emphasising the significance of time in determining task duration and sequencing. Ittner et al. (2003) also emphasise the importance of establishing time limits for completing tasks to track progress and ensure accountability while highlighting time as the framework by which organisations establish deadlines. Neely et al. (2004), meanwhile, discuss the necessity of checks and updates within the scorecard framework enabling organisations to assess task effectiveness over time and make any necessary adjustments. Time naturally also facilitates the ability to identify performance trends and patterns—making it easier to spot areas for improvement—and carries weight within the scorecard framework by allowing for alignment with long-term goals, schedule management progress monitoring, and continuous development.

Open-book accounting (OBA)

The open-book accounting (OBA) concept refers to the arrangement where suppliers and buyers disclose and share their costs and other data generated by their accounting systems (Romano & Formentini, 2012). By implementing this, organisations aim to achieve several objectives starting from finding cost reduction opportunities to offering resources for the development of the network members (Kajüter & Kulmala, 2005). However, these aims cannot be met without the six prerequisites of a successful relationship: commitment, trust, communication quality, participation, coordination, and joint problem-solving (Kulmala, 2002). Moreover, OBA requires a sophisticated cost accounting system in place in order to generate accurate and reliable cost data for sharing (Caglio, 2018). Seal et al. (1999) find that this challenge is the reason that prevented a UK supplier-customer partnership from success. Due to the weakness of internal cost systems, the partners reached cost savings limited to a narrow scope while their plan was to go beyond that. The authors suggest that an ABC system and the BSC scorecard would certainly assist in measuring intra-company costs and defining non-financial benefits among the OBA partners.

According to Håkansson et al. (2010), the OBA practice can take several arrangements and types. First, the cost and financial data can be shared between two entities only (dyadic) or among multiple partners in the same network (multilateral). Secondly, suppliers can share planned cost data while others may disclose actual numbers. The third dimension is related to the amount of data disclosed, where some firms disclose detailed information about the cost of their products and services while others disclose partially. Fourth, the disclosure of information can take one-way or two-way flow. In other words, in some relationships, one partner has to disclose information but not vice versa. On the other hand, both partners have this obligation to exchange data in other arrangements. Finally, the OBA practice can be seen from the perspective of basis. Some arrangements are shaped based on the power in one’s hand and some based on mutual trust between both parties.

The OBA practice has been studied in the literature from different perspectives that serve different sectors. In the automotive sector, OBA is instrumental in bolstering trust and satisfaction between suppliers and buyers, as delineated in a study by Fehr and Rocha (2018). Similarly, the manufacturing sector utilises OBA for the dissemination of cost data and financial information, aiding in the cultivation of robust buyer-supplier relationships, as expounded in a study by DhaifAllah et al. (2019). In the construction sector, OBA practices contribute to enhanced project management and cost control, facilitating cooperative procurement procedures pivotal for project performance and cost management, as discussed by Eriksson and Westerberg (2011). Additionally, the circular economy model, as discussed by Lacy and Rutqvist (2015), showcases the application of OBA practices in waste management and resource optimisation across various industry sectors including retail, technology, and manufacturing, with companies like Dell, Airbnb, Uber, and IKEA among others, employing OBA practices to transition towards a circular economy.

Conclusion

The history of logistics activities is rooted in ancient times when moving food, goods, and people were part of humanity's needs. However, the recent developments in technology and trading have resulted in the emergence of logistics as a new managerial discipline aiming to optimise operational efficiency. Nowadays, companies prefer to outsource their logistics operation to logistics providers as a new way of achieving higher efficiency and customer service excellence. As a result, new models of logistics companies have been observed, such as 3PL, 4PL, and 5PL. This chapter focused more on the 4PL companies as this study investigates the role of the TD-ABC system in modelling the 4PL activities. Several innovative tools were suggested in this chapter that can help logistics providers in general, and 4PL specifically, manage their financials effectively.

Chapter 3 : Literature Review – The Costing Models

Introduction

The history of costing model developments can be traced back to the second half of the 1800s when the textile mills and railroad companies had started to find ways to plan the processes of their primary activities (Kaplan, 1984). Lyman Mill, an English company established in 1855, used their double-entry accounting book to enable their managers to monitor the conversion cost of raw materials into finished goods. This system is considered one of the earliest cost accounting systems (Johnson, 1972). Since then, a considerable number of costing models have been developed to keep pace with the three Industrial Revolutions that have changed the way of production and marketing. For example, the SC system was introduced at the beginning of the 20th century to reflect the change in the organisations' size and structure. In the late 20th century, however, this model was not relevant to the new trend in production that focuses more on activities rather than products. Therefore, the ABC system was invented in the 1980s by General Electric. In 2004, (Kaplan & Anderson, 2004) developed the TD-ABC model as a new version of the ABC system to overcome some reported flaws that could prevent users from obtaining the best results. Other costing systems were invented or modified from other systems, such as Resource Consumption Accounting, Throughput Costing Systems, and Absorption Costing Systems. However, this chapter focuses on the three central systems – SC, ABC, and TD-ABC – as they're relevant to this research's scope.

This chapter consists of four sections. In Section 3.1, the researcher sheds light on the SC system – how it started, the system model, and advantages and disadvantages. The researcher discusses the ABC system in Section 3.2. Similar to the previous section, the system's history, design, and strengths and weaknesses are discussed in sub-sections. Section 3.3 focuses on the TD-ABC system in more detail than the previous two sections. The researcher elaborates on the system design steps, structure errors, and advantages and disadvantages. Finally, Section 3.4 reviews studies that discuss the application of TD-ABC systems in logistics.

3.1 The SC model

At the beginning of the 20th century, the structure of organisations had become more extensive and complex, with multiple divisions. Giant companies such as Du Pont, General Motors, and Sears introduced new lines and products to their existing ones. This development in the business world then created the need for more coordination between the organisations' divisions and for control of the various product standards, policies, and procedures. (Johnson & Kaplan, 1987). In other words, there was a need for a new accounting system that could provide reliable reports to the top management. In 1918, G. Charter Harrison was the first writer to publish a guiding set of equations to analyse the variance between standard and actual costs. That set aimed to provide a control tool to help management to control operations. In addition, accountants used it to value inventories for financial statements preparation (Johnson & Kaplan, 1987). That innovative work by Harrison paved the way for some early-adapters to embrace SC as a new model of tracing labour and production costs.

The SC model design

All previous developments in cost accounting systems focused mainly on one element of the total cost, which is the direct cost of labour and materials. They didn't consider the allocation of overhead and depreciation (Kaplan, 1984). Therefore, the scientific management movement led by Frederick Taylor and others proposed a new scientific methodology to standardise the workflow of processes and to measure and allocate the overhead costs accordingly (Kaplan, 1984). At the beginning and middle of the 1900s, fixed costs were allocated based on the volume of production, where a standard overhead cost rate was predetermined. At its core, the SC model needs two pieces of information: the department-estimated total overhead cost and a relevant cost driver, which is the estimated labour or machine hours, mostly. In some cases, different cost drivers, such as the estimated number of orders, can be used instead. By dividing the total overhead cost by the estimated cost driver, we should obtain the so-called "predetermined overhead rate". Hence, when a department desires to allocate overhead cost to a particular cost object (e.g. order, customer, or product), it will need to multiply that rate by the number of outputs. For example, if the department uses the estimated machine hours as a base to allocate the estimated overhead cost, and the rate is $2 per hour, an order that needs 2 hours of work should be allocated $4 as overhead cost (Figure 3-1).

The SC model's advantages and disadvantages

The standard cost system had shown its advanced capability to allocate the overhead costs to the cost objects and to report the idle capacity costs. The scholars, consequently, paid attention to this innovative model. They published a series of articles that endorse the feasibility of this approach as a reliable and established way of overhead allocation (Kaplan, 1984). The success of this model was attributed to two reasons. First, the indirect costs formed a small portion of the total costs, whereas the direct costs were the majority and could be traced easily. Second, at that time, production was characterised by features such as limited product ranges, production in bulk batches, and the relative absence of customisation requests in orders. However, this inherent simplicity became irrelevant after the 1980s, when technology boomed incredibly, substituting human-based resources and flipping the "direct vs indirect costs" equation (Kaplan & Cooper, 1988). The competition among businesses had become more intensive and had forced manufacturers to accept low-quantity orders with high-customisation requirements. The traditional costing system had become irrelevant as it couldn’t capture the product demand on the company’s resources. As a result, it become apparent that there was a need for a new costing model that can keep up with those dramatic changes.

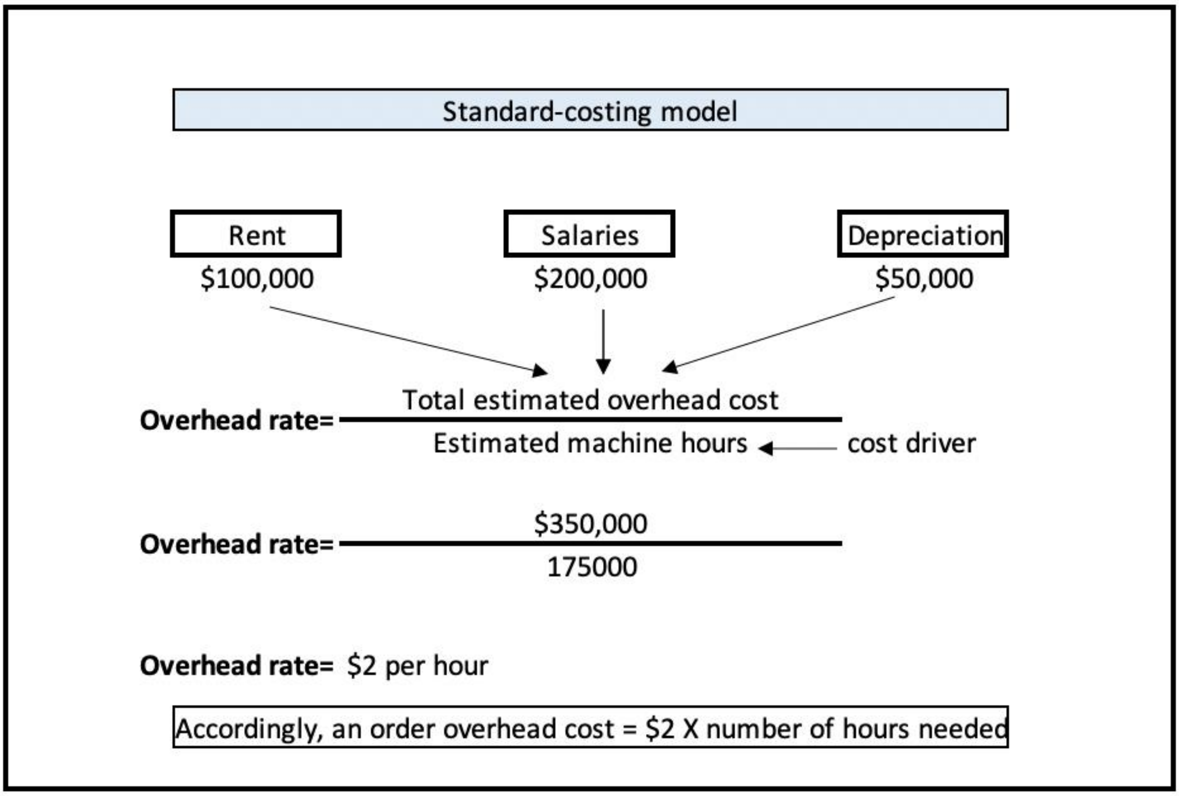

Figure 3-1: The SC Model Design

3.2 The ABC model

The SC system was relevant to companies at a certain level of operational complexity. When new trends and technologies arose with the 3rd Industrial Revolution, the SC system could not produce cost information with the desired accuracy. Kaplan and Cooper (1988) attribute this loss of relevance to the radical change of the cost structure in manufacturing companies due to the increase of overhead cost as a proportion in the total cost. In the mid-1980s, some big companies such as General Electric developed their costing systems to overcome the traditional one’s dilemmas and to enhance their cost information usefulness (Johnson, 1992). The ABC model was consequently developed to understand the relation between the performed activities' costs and the related cost objects such as products and customers (Cooper & Kaplan, 1992). This high level of sophistication in the ABC model granted the decisionmakers accurate cost information that could support their strategic decisions (Bjørnenak & Mitchell, 2002; Cooper & Kaplan, 1992; Pohlen & La Londe, 1994). In addition, it enhanced the efficiency of performance by eliminating or reducing the number of unnecessary tasks (Pohlen & La Londe, 1994) and providing financial and non-financial performance measures (Parker, 2000; Pohlen & La Londe, 1994; Taticchi et al., 2010).

The ABC model design

The core distinction between the SC and ABC systems is the allocation base. While the former allocates the cost of the resources (rent, salaries, equipment, etc) to the products directly based on the inputs-used or outputs-produced basis (e.g. the number of units produced or the number of labour hours), the ABC model assumes that products don't consume resources directly, they consume activities first. Then, the cost of these activities should be allocated to the cost objects (e.g. customer, products, services, or channels) based on different but relevant cost drivers that align with the nature of the activities (Figure 3.2). This advancement in the ABC methodology enables managers and cost accountants to trace product cost accurately, especially when there is a complicated mix of products and customisations. Cooper (1990) defines five steps to design an ABC model as follow:

Step1: Defining and aggregating activities

The first step in designing an ABC model is to define the firm's activities in delivering its products and services. The activities are actions or events that build up the value chain. In some firms, these activities are vast and complicated, which may lead the ABC project to failure due to the loss of control. Therefore, it's preferable to aggregate activities that link to each other and have the same cost driver. For example, machine maintenance and machine operation are two different actions, yet they can be treated as one single activity as they have one cost driver, machine hours. Over-aggregation, on the other hand, could form another flaw in the costing system as it will cause a lack of accuracy in the cost information. Therefore, the company must ensure a balanced activities aggregation to overcome the implementation complicity and avoid the lack of accuracy in the cost information.

Step 2: Reporting the costs of activities

Now, the calculation of the indirect and sharing costs of performing activities is needed. Since such costs cannot be allocated to the products directly, cost drivers are needed to allocate these costs to activities first and then to the products. Examples of such costs are administration, rent, and depreciation. In the ABC system, department managers provide their opinions periodically to the financial controller (or cost accountant) about how the total indirect costs should be assigned to activities. For example, let's assume that the distribution department performs three activities: receiving items, order fulfilment, and inventory control. The total indirect cost for this department, which consist of wages, warehouse rent, and depreciation, are $300,000. The department manager should allocate the $300,000 to the three activities (by percentage) depending on the amount of work the department dedicates to each activity; let's say 20, 60, and 20% respectively. Hence, each activity will be assigned a portion of the total indirect costs as it is responsible for that consumption.

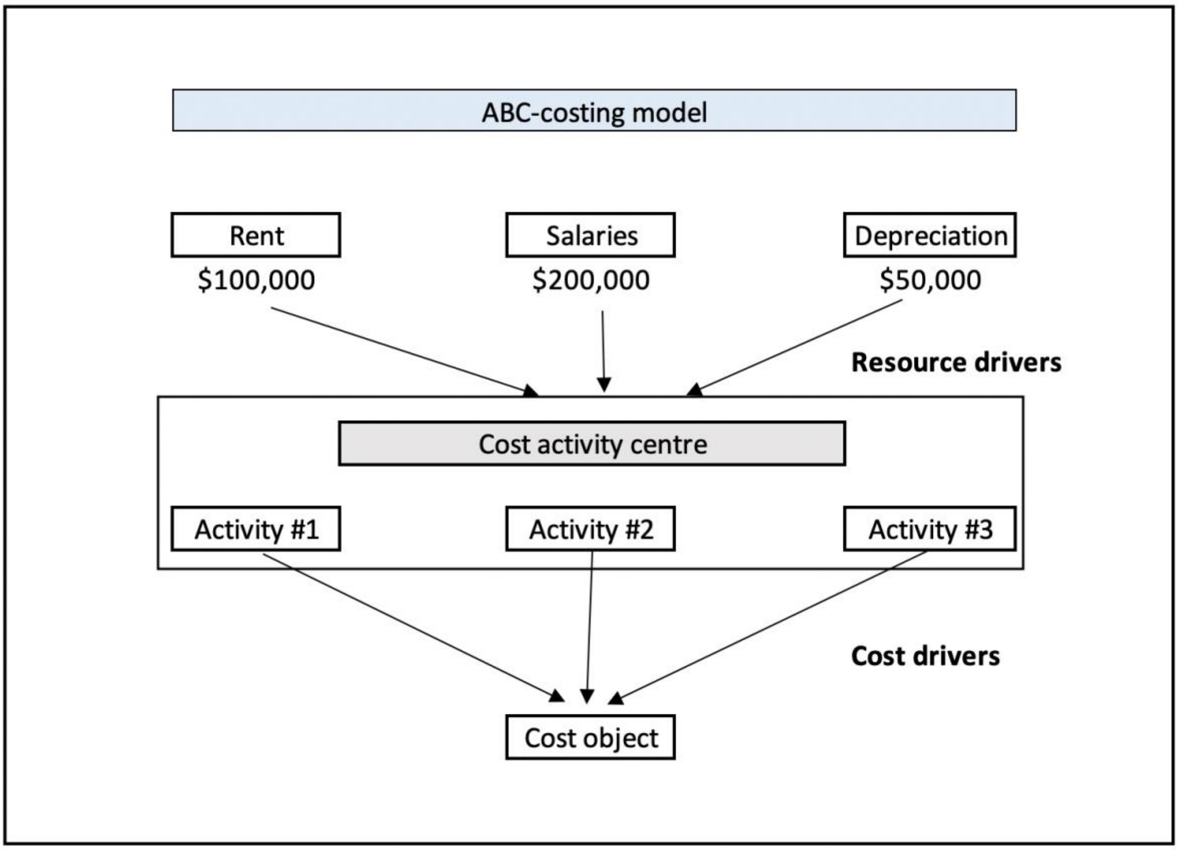

Figure 3-2: The ABC model based on (Everaert et al., 2008)

Step3: Identifying activities centres

According to (No & Kleiner, 1997, p. 70), an activity centre is "a segment of the production process for which management wants to report the cost of the activities performed separately". The activities centres are the departments that perform various activities. For example, the engineering department is an activity centre. This centre performs multiple activities that consume resources (indirect cost). Pooling these activities in one centre allows us to accumulate all costs in one individual pool before we assign them to the cost objects (e.g. products, departments, customers). An evident example of how the costs of a specific department can be allocated to another department can be seen in the supporting departments (e.g. the human resource department). The cost of activities that such departments perform should be allocated to the operating department proportionately as they incur costs to support operations. Therefore, identifying separate activity centres is an essential step in developing a successful ABC system.

Step4: Assigning first-stage drivers

In this step, we assign resource cost drivers where we allocate resources such as rent, wages, and equipment depreciation to the activity centres. Each activity centre consumes a fraction of the total resource costs to implement its activities. Hence, we need to assign one resource cost driver per each resource. For example, admin. and supervision salaries can be allocated to the various activity centres based on the number of people working in that centre. Rent expenses can be allocated to a specific centre based on space utilisations, and so on.

Step5: Assigning second-stage drivers

Each activity centre has been assigned a portion of the total overhead costs needed to run its activities. The next step is to allocate this portion to the cost objects that demand our activities. The ABC system, as mentioned earlier, allocates resources cost to the various activities first, and then the activities allocate costs to cost objects (e.g. customers) based on different activity drivers. The second-stage drivers represent the consumers of the cost centre's resources. In any customer service department, handling customers' inquiries consumes a significant portion of the department's resources. A logical base to allocate this cost is the number of tickets handled. If the department, for example, estimates to handle 1000 tickets per month, and this activity represents 40% of the total activities implemented by the department, we should allocate 40% of the total department's costs to the 1000 tickets evenly. Accordingly, each customer (the cost object in this case) will be charged based on the number of tickets it raised.

The ABC advantages and disadvantages

The shortcomings in the SC model have encouraged practitioners, consultants, and researchers to explore different views of overhead cost allocation, management, and control. The ABC model proved its superiority in meeting this need when several giant US companies started successfully implementing it, and it has been widely accepted after that. Swenson (1995) surveyed 60 managers representing 25 firms working in different industries to explore the benefits of using the ABC model. The managers reported that their confidence in the cost information accuracy had been enhanced after the ABC adoption. Consequently, the new system has been used as a robust tool that helps managers make strategic decisions, such as product outsourcing decisions. In addition, 72% of firms surveyed stated that they use ABC to support their pricing and product mix decisions. Lere (2000) emphasises this advantage and attributes it to the notion that the ABC system can capture the cost of specifications in products. The third reported advantage found in the ABC model adoption is the feasibility of this system as a powerful tool to analyse the customer profitability. The ABC system can recognise the costs of primary and sub-activities implemented to serve each customer. As a result, managers can use ABC to evaluate and segment their customers for future decisions. Many other benefits were found in (Swenson, 1995) and other studies, such as the use of this model to support process improvement and product designs.

Like any other system, the literature reported several flaws in the ABC system that hinder many companies from adopting or continuing with it. First, the proponents of this methodology argue that it is challenging to implement and maintain the ABC model since it requires surveying people periodically to estimate the time needed to perform activities, which is time-consuming (Kaplan & Anderson, 2004). "ABC systems were expensive to build, complex to sustain, and difficult to modify." (Anderson & Kaplan, 2007, p. 6). For example, Compton Financial Group's management (a large US company) needed a 33-day cycle to generate ABC monthly reports (Anderson & Kaplan, 2007). Secondly, the accuracy of cost information generated by this system is doubtful as it relies heavily on personal estimates when allocating costs to activities (Anderson & Kaplan, 2007; Blaschke et al., 2020; Zamrud & Abu, 2020). Finally, the ABC system cannot distinguish between the utilised and idle capacity costs. As the system requires people's estimates for time allocation, people tend to allocate 100% of their theoretical capacity to work (Blaschke et al., 2020).

ABC's success and failure

Since its invention, implementing ABC systems has been associated with many success and failure stories. Some firms have successfully implemented this model and enjoyed its benefits, and others have failed. Therefore, many scholars have paid attention to studying the variables that affect the results of ABC implementation and provide insights to the new firms that may consider adopting this sophisticated model. Starting from the early age of this innovative system, (Shields & Young, 1989) developed a theoretical model to assess the factors that play crucial roles in the success of the implementation of cost management systems. This model suggests that the cost management systems, including ABC, are administrative innovations, not technical innovations. Consequently, the factors that affect the success of such systems are behavioural and organisational variables such as management support and the linkage between these systems with firms' strategies, goals, agendas, and more. The technical variables, on the other hand, such as the type of software and whether it's integrated or stand-alone, are not considered as effective and robust as many believe, according to the authors.

Cooper and Kaplan (1992) practically proved the theoretical model developed by (Shields & Young, 1989) by studying eight companies that had implemented the ABC system and experienced either successful or failed results. This case-study-based research focused on why companies encounter difficulties while implementing the ABC systems. These difficulties are enough to justify the success and failure experience. The researchers have found that most problems are attributed to a few organisational and behavioural variables. First, the ownership of ABC had been found, in most firms, under the accountants' responsibility. This organisational flaw disconnected the linkage between the ABC system and the performance evaluation. The ABC system is not only a costing tool but a strategic means to improve the overall firm's performance. Second, the researchers claim that the probability of success of ABC implementation rises when a firm assigns a number of employees to manage this project at an early stage, and this group must be supervised by a member of the top management. Finally, the natural employee resistance to any new system can lead to implementation failure. The same problem was found in this study, where the researchers reported that the ABC system was considered complicated and a disaster by some employees in the studied firms. According to the researchers, the solution to this issue is to involve people from different departments in this project and train them adequately on how to manage the system, as they will be the primary users of its information.

Although the previous research assures that the organisational and behavioural factors have the most substantial effect on ABC's success, the technical considerations that may lead to the system's failure should not be neglect. Kaplan and Anderson (2004) claim that the technical complicity behind the ABC system forces many businesses to abandon its use of it. As shown in the second step of the ABC design above, the managers should perpetually provide their subjective estimates about the time spent on each activity to allocate a part of the department's cost to that activity. That means the cost data are subject to errors as humans estimate them. Moreover, these data are subject to being obsolete if the company has no maintenance plan. Another technical issue is the selection of the main activities and costs drivers. The ABC models are tricky when it comes to the design stages. Lievens et al. (2003) state that the precision of ABC systems depends on the details that should be included in building the system. The accuracy of cost data generated by ABC systems needs a moderate aggregation of activities and cost drivers that represent the reality of cost behaviour in the firm. Disaggregation as well as over-aggregation are significant drawbacks to any ABC system as the former causes more complexity and the latter leads to loss of accuracy.

3.3 The TD-ABC model

Companies work under intense pressure in today's competitive business environment to provide customers with high-quality products and services at affordable prices. This hard-to-achieve equation needs a sophisticated cost management technique that accurately captures the process, products, order, and customer cost information. The TD-ABC model was introduced in 2004 by (Kaplan & Anderson, 2004), aiming to update and solve the flaws and problems associated with the ABC model. Kaplan and Anderson state that the TD-ABC model can resolve time wasting, difficulty to scale, and other problems that have been found in the adoption of the ABC model. Moreover, it can be installed, updated, and validated quickly and easily. The TD-ABC model's main idea is to incorporate equations that reflect the time needed to perform each activity within the entire process. Accordingly, the cost of each activity will be the prodduct of the time spent on that activity multiplied by the cost rate per unit time, which is usually in minutes (See equation 3-1). This technique should provide insights into how the company is utilising its resources and what actions are needed to maximise the efficiency and productivity of those resources. According to (Kaplan & Anderson, 2004), the TD-ABC technique has capabilities that have been effective even in complex business settings with various customer characteristics, products and services, and processes.

$$\text{Activity Cost} = \text{Time Required For Activity X Cost Rate per Unit Time}$$

Equation 3-1: Generic TD-ABC equation

The TD-ABC model design

To some extent, the TD-ABC model is similar to the ABC model as it has been built based on the ABC’s mechanism yet further developed to overcome the difficulties found in the ABC implementation. The similarity between these two systems is rooted in the choice of activities to be the heart of the two systems. In contrast to the SC model that allocates overhead costs directly from departments (resource pools) to cost objects, the ABC and TD-ABC systems allocate overhead costs from departments to activities first. Then, they distribute the overhead cost from activities to the cost objects. However, the two systems differ in how they implement the second step. While the former uses the number of transactions as the cost driver, the latter embraces time as the main cost driver. In the TD-ABC system, time plays a significant role in capturing the cost of activities and allocating the overhead cost from activities to the cost objects. Anderson and Kaplan (2007) claim that the time equations mechanism makes the TD-ABC model capable of capturing complex activities more efficiently and quickly than the traditional transaction-based system.

In the previous studies that discuss the TD-ABC model design, researchers present different ways to develop the TD-ABC model. Although they all agree on the core of the model introduced by (Kaplan & Anderson, 2004), researchers disagree on the numbers and names of steps needed to design the system. For example, Ma (2014) developed a TD-ABC model in only three steps: calculating the CCR, developing the time equations, and calculating the cost of operation by multiplying the CCR and the time of operation. Kim et al. (2016) introduced their four-step model: estimating the unit cost per resource pool, estimating the rate of resource consumption per activity, deriving the cost driver rates, and calculating the cost of operation. Öker and Adigüzel (2010) present the TD-ABC model in five steps: grouping resources in pools, calculating the CCR per pool, developing time equations, calculating the total capacity demanded by each pool, and calculating the total capacity demanded by each cost object. Finally, Everaert and Bruggeman (2007) elaborate more with their six-step TD-ABC model. The researchers suggest identifying the resource pools, estimating the overhead per each pool, calculating the practical capacity, estimating the time per event, calculating the CCR per pool, and finally multiplying the last two steps. This disagreement between scholars on the number and names of the steps should not be of consequence the model's results. As mentioned earlier, the principle of the models developed in these studies is still derived from the original work introduced by (Kaplan & Anderson, 2004), which is explained in the following three steps:

Step1: Calculating the CCR

The CCR is the result of dividing the total cost of the resources supplied, such as people, machines and equipment, trucks, and facilities, by the practical capacity of resources supplied per department or resource pool (Equation 3-1). As each part of this equation needs more elaboration on how to obtain it, the following sub-sections discuss them in more detail.

$$\text{CCR} = \text{Resources Supplied}/\text{Practical Capacity}$$

Equation 3-2: The CCR Equation

The Resources Supplied

The resources supplied are the total overhead cost supplied to a specific department or resource pool. This number shall be available in the company's financial accounting system, consisting of multiple categories such as salaries, rents, depreciation, and other indirect costs. Anderson and Kaplan (2007) emphasise that the TD-ABC model should incorporate operating and supporting departmental costs. As not all departments touch the product or service, the model designer should not ignore the costs of the servicing departments to be included by assigning them to the operating departments. For example, the human resource department is not involved in production directly, yet it helps the operating departments by supplying them with the required manpower and other related services. Anderson and Kaplan (2007) claim that the sound TD-ABC model should assign this department's costs to the beneficiary departments (e.g. the production department) in a way that allows the total company's overhead costs to be incorporated in the final product.

The Practical Capacity

The practical capacity is the time available to work in a specific department, which is the denominator of the CCR equation. Kaplan and Anderson (2004) suggest that the practical capacity figure can be obtained in two different ways. First, the arbitrary approach assumes a certain percentage of the theoretical capacity, say 80 or 85% of the total time. Or, secondly, by using the analytical approach that implies that the resources are available for a certain number of days during the year, we deduct the breaks, training, maintenance, meetings, and all other times that those resources are not available. The information about the practical time can be obtained by interviewing the departments' heads who can provide information about the teams' workdays, break times, training hours, and more. According to Kaplan and Anderson (2004), both approaches should lead to a reasonable level of accuracy. "It's important not to be overly sensitive to small errors. The objective is to be approximately right, say within 5% to 10% of the actual number, rather than precise." (Kaplan & Anderson, 2004). This flexibility in the model design process resulted in a clear division between the researchers who developed TD-ABC models after that. While researchers such as (Everaert et al., 2008; Somapa et al., 2012) followed the random approach assuming that the practical capacity is 80% of the theoretical capacity, others such as (Afonso & Santana, 2016; Au & Rudmik, 2013; Ma, 2014) preferred to embrace the analytical approach, and they have generated various results.

The practical capacity could be measured in different units besides the time ones. For example, offices, warehouses, databases, and vehicles have various units of measurement. Kaplan and Anderson (2004) suggest using the proper unit of measurement for each type of resource. Spaces in offices and warehouses could be measured in square or cubic metres, vehicle capacity can be calculated in kilometres (km), and databases capacity can be captured by the megabyte or whatever unit suits this resource more. The application of these diverse measurement units in the TD-ABC system could lead to the question about using the term time in the model's name instead of resource, for example. The latter term allows for broader inclusion of all types of resources instead of focusing on one, which is time.

Step2: Estimating time consumption

The second step toward developing a TD-ABC model is estimating the time of events that occur in the operating departments. The model developers need to analyse all steps and durations for the entire process cycle using a unit of time such as minutes. For example, if producing product X requires three steps, A, B, and C, the developers need to estimate the time needed to implement each step before they add them up to determine the total time demanded in product X's production.

Anderson and Kaplan (2007) recommend that researchers and developers not seek precision when collecting time data. Instead, they recommend following one of the reasonably accurate methods, such as direct observations, interviews with employees, using existing process maps, and using company or industry available benchmarks. These suggested methods imply that the TD-ABC model's innovators assume that the standard time is enough for the model's accuracy.

Step3: Developing the TD-ABC equations

Most operations have different levels of complexity. Some transactions need more time than others, and this variation comes from either internal or external factors. "Transaction characteristics cause processing times to vary." (Anderson & Kaplan, 2007, p. 27). Thus, the cost system needs to be capable of capturing these variables effectively. Kaplan and Anderson (2004) claim that the most evident advantage of the TD-ABC model is the capability to capture complex operations. This strength is derived from the time equations that allow incorporating process characteristics as variables. The cost system can then recognise the existing characteristics per each transaction separately and assign an overhead cost to that transaction accordingly. For example, if "Processing Sales Orders" activity requires ten minutes as a standard time to implement its standard requirements (standard characteristics) plus two minutes per each line item in that order, and if there is a chance to add five more minute in case the customer is new (conditional characteristic), and three more minutes if the customer requires a special packaging (conditional characteristic), the TD-ABC equation will be formed as follows:

Processing Sales Orders (minute): 10 + (2 * number of lines) + 5 if a new customer + 3 if special packaging.

Equation 3-3: "Processing Sales Orders" activity TD-ABC equation - Example

Since we have the CCR (step 1), capacity usage (step 2), and we have the time equations (step 3), the TD-ABC model is ready now to allocate the overhead cost to the cost objects. As Figure 3-3 shows, the TD-ABC model starts with accumulating the expenses of the resources (e.g. salaries, depreciation, etc.) into different pools representing the departments, locations, or any relevant categories. Next, the capacity rate for each pool should be determined to calculate the costs of that pool's activities according to the time equations. Finally, the cost of each activity can now be assigned to the cost objects (e.g. customers) according to their usage of time. For example, if customer A has one order that needs to pick and pack ten items from the warehouse, and customer B has one order as well but with five items only, the time equations for picking and packing activity should capture the difference in the number of item lines to distinguish between customer A and B. That's because customer A's order will consume more picking time than customer B. Not only this, but the equations should also capture the characteristics of the items in both orders. Some items may require more packing time than others. Interestingly, customer B's order may require more time eventually than customer A's even though the number of items is less. However, the time spent on packing the five items in the B order could result in consuming more resources than the A order, which has more but easier-to-pack items.

The TD-ABC model elements

Depicting the cost system in a flowchart is beneficial to define the operation scope and to determine the allocation complexities (Compton, 1996). As discussed earlier, the TD-ABC system is the upgraded version of the ABC one (Kaplan & Anderson, 2004). Both systems can be modelled using the same elements as they both fall under the ABM big umbrella. The core principle of cost allocation in the ABM systems is almost the same. The ABM systems follow the two-stage allocation method where resources pass down from resource pools to activities first and from activities to the cost objects second (Figure 3-3). The distinction between the TD-ABC and ABC systems is attributed to the nature of the cost drivers in the second stage when the resources pass down from activities to the cost objects. While the ABC system relies on the number of transactions as a cost driver, the TD-ABC uses time instead. However, this distinction does not prevent us from claiming that building a costing model following the ABC or TD-ABC system requires the same elements. According to (Compton, 1996), there are eight significant elements in any ABC (thus TD-ABC) model: resources, activity, activity centre, resource driver, activity cost pool, activity driver, cost element, and cost object (Table 3-1). Each one of those eight elements connects to another to model the cost system, as Figure 3-3 shows.

Element	Definition
1 – Resources	"Economics elements used to perform activities, such as management costs, facilities support, etc." (Compton, 1996, p. 23).
2 – Activity	Process or steps performed to generate outcomes. For example, the Procurement activity is a set of steps to make purchases.
3 – Activity centre	A group of related activities. It can be named Resource Pool as well.
4 – Resource driver	A factor used as a base to allocate resources to activities.
5 – Activity cost pool	The total cost allocated to a certain activity.
6 – Activity driver	A factor used to allocate cost from one activity cost pool to another or to a cost object.

7 – Cost element	"The amount paid for a resource and assigned to an activity" (Compton, 1996, p. 23).
8 – Cost object	The product, service, or customer who receives the cost at the final stage of allocation. This is the ultimate goal of any costing system.

Table 3-1: The TD-ABC model element

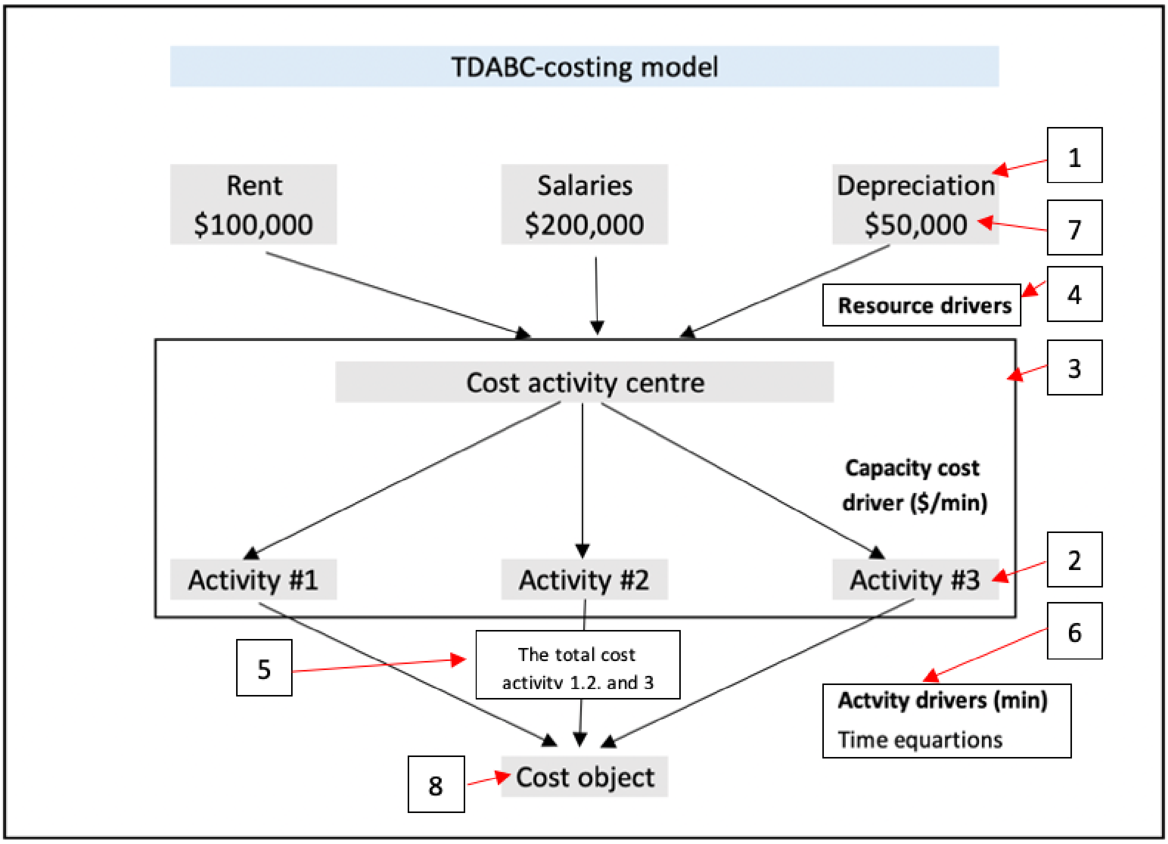

Figure 3-3: The TD-ABC model design based on:(Everaert et al., 2008)

The TD-ABC design errors

According to (Hoozée et al., 2012), TD-ABC is prone to estimation and identification errors. Identification errors occur when vital time equation elements have not been identified or added. On the other hand, estimation errors happen when driver volumes or time parameters have been determined using the wrong method or the wrong database (Labro & Vanhoucke, 2008). Several researchers have examined the experience of time using Vierordt's law, which states that longer time intervals are consistently underestimated, while shorter time intervals are always overestimated (Lueg & Morratz, 2017). Using a top-down technique on ABC, Cardinaels and Labro (2008) established that minute-based response modes deliver a strong overestimation bias at 37%. Their finding is consistent with the findings from (Schuhmacher & Burkert, 2014), which used a bottom-up method (TD-ABC) where the minute-founded response mode displayed a similar underestimation bias. Labro and Vanhoucke (2008) claim that measurement errors varied with aggregation levels in costing system activities definition, task coherence, and when notice is offered that time approximations will be needed. Estimation errors might also affect the driver volumes and transactional data (Labro & Vanhoucke, 2008). This occurs due to capturing inaccurate information within the organisation’s system, such as transactional entry issues or inventory level inaccuracies. Therefore, to get the required information from TD-ABC implementation, it is crucial to obtain detailed information during the initial implementation phases because the initial processes determine the accuracy and usefulness of cost systems (Öker & Adigüzel, 2010)

The TD-ABC advantages

The model simplicity

According to (Kaplan & Anderson, 2004), the simplified mechanism has featured the TD-ABC model over the traditional ABC system as it eliminates the need to survey people regularly; thus, it increases the accuracy of cost information. As Equation 3-1 above shows, the TD-ABC model can be built to capture as many terms (characteristics) as needed. Moreover, the model can be developed once and updated only when there is a significant change in the activity's time or steps. Anderson and Kaplan (2007) consider this characteristic in the TD-ABC model a significant advantage. According to the authors, the conventional ABC model embraces a massive dictionary of activities that reflect the complexity of operations. Each sub-process or sub-sub-process is counted as a separate activity in the ABC system database. In contrast, it falls under one main activity in the TD-ABC system. As a result, updating the activities dictionary requires significant time and effort in the ABC system, while it is easier and faster in the TD-ABC one.

The power to capture the complexity

Modern economies are characterised by complexity. Customers' needs are increasing with more customisation. Businesses need to cope with these changes by providing sophisticated but profitable solutions. According to its innovators, the TD-ABC system has been rewarded with the power to capture complex transactions in complex operation settings (Kaplan & Anderson, 2004). The power of the TD-ABC system is derived from the time equations that can accommodate as many variables as possible. Anderson and Kaplan (2007) state that the TD-ABC equations enable the system to go deeper to the level of individual transactions and to allocate overhead costs to customers, for example, based on the variables existing in that customers' transactions. Everaert et al. (2008) examined the TD-ABC system's capability to deal with complexity in logistics. The researchers developed a TD-ABC model for a company that has multiple sources of complication in its business model. In homogeneous tasks, variant customer groups and different order characteristics were causing pain to the case company as the existing costing system could not generate accurate information and scale up quickly. However, the researchers succeeded in developing a TD-ABC model that could trace every single task, customer, and transaction to allocate overhead cost based on the actual volume ratio of resource consumption. More interestingly, this power of calculating complex operations' costs is associated with less complexity in the system design. The new model reduced the number of activities in the company's database from 330 to only 106 (Everaert et al., 2008)

The identification of idle capacity

Another advantage of implementing the TD-ABC system is to utilise its capability to identify unused capacity. With these characteristics, managers become able to predict the demand in the resources (Kaplan & Anderson, 2004), which will help improve the resources utilisation (Afonso & Santana, 2016; Dejnega, 2011; Everaert et al., 2008; Gervais et al., 2010; Stout & Propri, 2011). Everaert et al. (2008) assert that the TD-ABC system is vital in complex environments such as logistics as it assists managers in measuring warehouse productivity based on available capacity. Some transactions consume more or fewer resources than others. The TD-ABC equations can capture this variation and calculate the used and unused capacity cost accordingly. Researchers such as (Afonso & Santana, 2016; Dalci et al., 2010; Järvinen & Väätäjä, 2018; Ma, 2014; Zhang & Yi, 2008) examined this feature and found that the efficiency of operation can be measured with the TD-ABC system. The researchers found various utilisation numbers ranging from 67% to 85% of the total available capacity in the cases studied. With this advantage, managers can make backed-up decisions to optimise operation efficiency by enhancing capacity utilisation or reducing the supplied resources.

The TD-ABC system as a benchmarking tool

The analysis of process, times, and capacity at which the TD-ABC system is sound, makes this system beneficial not only for cost but also as a control tool (Anderson & Kaplan, 2007). The researchers claim that the TD-ABC model outperforms other benchmarking tools as it can isolate the effect of variation in the process performance caused by variation in capacity utilisation. Everaert et al. (2008) believe that the TD-ABC system can be leveraged for benchmarking studies, especially in companies with multiple locations. The time equations set for one location can be compared with other locations, and best practices can be transferred accordingly. For example, the time needed to pick up items in warehouse A can be assessed by benchmarking it with the duration of the same activity in warehouses B, C, or N. Accordingly, the decisionmakers will have better visibility toward performance in each location. Thus, they can make sound decisions to improve efficiency in the less-performing entities (Everaert et al., 2008).

The TD-ABC system for enhancing business processes

One of the main advantages that (Anderson & Kaplan, 2007) attribute to the TD-ABC system is that it sheds light on the process flow step-by-step; thus, it can indirectly help enhance the business process improvement. For example, the TD-ABC system can complement lean management initiatives that reduce waste in the process and increase customer value. The TD-ABC and lean management practices investigate every single step in an organisation's process flowchart. However, lean management's lens does not consider the cost of the process as it is not a part of its scope. By integrating the TD-ABC system with lean management practices, companies can add the cost perspective to the existing flowchart and translate the documented process flow into a cost flow model for a specific department or process and enterprise-wide (Anderson & Kaplan, 2007).

The TD-ABC system for cost reduction

Anderson and Kaplan (2007) find that the TD-ABC methodology and outcomes can be utilised to discover cost reduction opportunities by analysing capacity utilisation. As the TD-ABC system can distinguish between the cost of used and unused capacity, managements have a clearer visibility to decide whether to reduce the capacity supplied and, thus, the associated cost. Management also can reduce the cost of operation by optimising the resources supplied. For example, Popat et al. (2018) discovered that the cost of operation rooms in clinics could be reduced by up to 14% through personnel reallocation and changes to the workflow. This finding was an outcome of implementing cost analysis using a TD-ABC model.

Another stream of cost reduction opportunities comes from making or buying services. Managers can use the TD-ABC analysis to compare the cost of activities when implementing services in-house or externally. For example, Adioti and Valverde (2013) used the TD-ABC system to study the cost of providing IT services by the IT department to operating departments in the same company. The TD-ABC analysis revealed that 75% of the overall IT department’s cost was attributed to one type of service that constituted 30% of the incidents. This information can benefit the company’s management to take actions such as outsourcing, increasing the charge-back, or controlling the service cost.

The TD-ABC system for customer profitability analysis

The primary aim of any business is to maximise its profit. To achieve that aim, businesses need to know accurately how much it costs to make products and provide services. The cost systems play an essential role in managing that goal. With more accurate cost information, the system can help management make better decisions to enhance profitability. Kaplan and Anderson (2004) claim that the TD-ABC system can better serve this aim than any other traditional system. The authors suggest employing the TD-ABC method for CPA as they believe that customer profitability is more important than product profitability, especially in service-based companies. The CPA method is a tool that assists companies in understanding the profitability of their customers in relation to the cost of serving them. However to gain an understanding it is crucial to determine the costs associated with serving each individual customer (Anderson & Kaplan, 2007).

When CPA and TD-ABC are used in conjunction they can offer more valuable insights. For instance, companies can identify which customers are more expensive to serve and the underlying reasons behind it. Based on this information they can decide whether to continue serving these customers as before or make changes to reduce costs (Anderson & Kaplan, 2007). This enables companies to make decisions aimed at increasing their profits. Furthermore, employing both CPA and TD-ABC together allows companies to learn from their experiences and continuously improve over time. By assessing the costs and profits associated with each customer, companies can discover ways to provide services at a lower expense. This ongoing evaluation and enhancement process contributes towards long-term profit growth for businesses (Anderson & Kaplan, 2007).

Several previous researchers developed TD-ABC systems to study how this methodology can help companies analyse the profitability of their customers. For example, Everaert et al. (2008) used the TD-ABC system for CPA in a wholesale company that moved from ABC to the TD-ABC system. The study reveals that 20% of the case company's net profits come from 20% of its customers, while another 30% are responsible for losing 100% of the net profit. The remaining 50% of customers were at the breakeven point level. Dalci et al. (2010) investigated the customer profitability for eight group segments in a hotel using the TD-ABC allocation method. The researchers found that the eight groups' contribution to the hotel's net profit ranges from 2% to 42%. Regardless of the profit numbers and patterns mentioned above, these studies can confirm that TD-ABC is a powerful means for profitability analysis.

The TD-ABC disadvantages

Data collection difficulties

Kaplan and Anderson (2004) state that one of the most advantageous characteristics of the TD-ABC methodology is the simplicity of model development. The authors suggest that researchers and system designers can interview managers to estimate task duration and practical capacity. However, this data collection approach could compromise accuracy, which the authors repeatedly proclaim as a primary distinction of the TD-ABC system. The TD-ABC model has been criticised in some previous studies for its heavy reliance on-time estimations, which require a vast amount of data to model reliable time equations (Afonso & Santana, 2016). Barrett (2005) argues that employee estimates are significantly subject to bias. Cardinaels and Labro (2008) proved this problem in their experimental study when they found that around 77% of employees overestimate the tasks' implementation duration by 37% when they report time in minutes. In addition, researchers such as (Gervais et al., 2010; Hoozée et al., 2010) found that employees feel less comfortable being asked about their working times. Consequently, they may report unprecise times (Gervais et al., 2010) or even resist the TD-ABC system implementation (Reddy et al., 2012).

Barrett (2005) states that the TD-ABC system should be fed from reliable data sources to generate reliable cost information. Varila et al. (2007) agree with (Barrett, 2005) statement and emphasise that the required amount of data to develop satisfactory TD-ABC equations should be considerable. Accordingly, the researchers and designers may use multiple direct observations and information systems outcomes as replacements for the employee estimates. Although these means are less vulnerable to subjectivity, collecting data requires intensive effort and advanced technologies. Gervais et al. (2010) claim that the desired level of accuracy in the TD-ABC system makes the implementation lengthy and costly. Researchers who use personal observations need to repeat this task multiple times to ensure the reliability of the collected data, which means more effort, especially in environments with a large number of activities and variations (Varila et al., 2007). Automatic data collection tools such as radio frequency identification (RFID) could solve this issue in the TD-ABC system (Bahr & Price, 2016; Varila et al., 2007), but it is not available to all businesses, especially SMEs.

Activities identification difficulties

The TD-ABC methodology positions activities as the hub of the system. Resources pass down from cost pools to cost objects through activities. However, the identification of activities is a complex step. Previous TD-ABC studies reported several difficulties mostly related to some types of activities. For example, Cheporov and Cheporova (2014) claim that the TD-ABC system is not ideal for activities that rely on creativity and thinking. The start and end times and the boundaries of such activities are ambiguous. Cardinaels and Labro (2008) state that the TD-ABC system loses its accuracy with incoherent tasks that cannot be systematically structured. Examples of these tasks can be found in research and development, marketing, design, and IT activities. Wegmann (2010) agrees with this shortcoming in the TD-ABC system. The researcher claims that the ABC system outperforms the TD-ABC system with such activities as more mistakes are possible when structuring incoherent tasks. In contrast, he suggests using the TD-ABC with activities that can be standardised, such as those in production, call centres, and hospitals. Hoozée et al. (2010) found that the ABC system is more accurate than the TD-ABC in calculating the cost of such activities, especially when unused capacity is low.

3.4 The TD-ABC system in logistics

Since 2004 when (Kaplan & Anderson, 2004) introduced this new costing model, the role of the TD-ABC model has been investigated in many industries and contexts such as the supply chain, manufacturing, health care, hospitality, education, and technology. Interestingly, the number of publications discussing the TD-ABC model has been growing noticeably, especially those focusing on empirical studies. Therefore, since this research is also categorised as an empirical study, the following sections review similar studies published so far in the supply chain literature.

The first empirical study in the supply chain literature to discuss the role of the TD-ABC model was (Bruggeman et al., 2005), which was released as a working paper, and published later (Everaert et al., 2008). The researchers modelled the logistics operation costs at a Belgian wholesaler using the TD-ABC model. Then they compared the results with the previous outcomes generated by the ABC model. The purposes of this comparison were to identify how the logistics costs will be modelled using the TD-ABC approach, to identify whether the TD-ABC model provides more accurate information than ABC, and to understand how the decisionmakers will use the TD-ABC cost information. The findings show that the TD-ABC approach has successfully modelled the logistics activities costs, especially the ones that can't be modelled using the ABC due to its shortcoming in modelling the transactions with multiple cost drivers. The study also found that the cost information provided by the TD-ABC model is more accurate than the figures provided by the ABC model. Consequently, this has helped the case company's management to make better decisions to enhance customer profitability.

Anderson and Kaplan (2007) argue that adopting the TD-ABC model is vital to enhance the profitability of both vendors and customers. In addition, it transforms non-profitable relationships into profitable ones when the vendors and customers open their doors for collaboration and sharing of their transaction data. To illustrate this, Anderson and Kaplan (2007) give a real example of two companies called Clairmont (vendor) and its customer Frontier that were in a non-profitable relationship. Frontier believed that the $2 million in gross margin generated from selling Clairmont's products was enough to cover all other operating expenses, including the supply chain. On the other side, Clairmont believed Frontier was a profitable customer since they placed more than 13,000 orders yearly. However, when the two companies decided to develop a TD-ABC model, interestingly, they both found that their relationship was not profitable due to the inefficient supply chain processes from both sides. Too many small-size orders from Frontier had caused an increase in the supply chain costs incurred by Clairmont from $211,000 to $1,040,000 per year. Similarly, Frontier had discovered a 275% increase in the supply chain costs due to its decentralisation strategy for distribution centres, which had resulted in an inefficient supply chain performance at each centre. These incredible and terrifying results would not have been discovered if the TD-ABC model was not in place and the two parties were not open to sharing their data.

Varila et al. (2007) discuss the usage of time duration as a cost driver instead of relying on the number of transactions, as the ABC model is built based on. The actual times were used with the help of bar code technology that collects the duration of the event and feeds the cost accounting system with real-time data. Beyond that, the study analyses the causes of variation in the time durations in one case activity, namely the picking and packing activity, at an electronic company warehouse. The number of receipts, total weight, the number of units, product group, total volume, receipt method, and the additional handling requirements are the variables that were observed and analysed statistically to understand their impact on the case activity duration and costs. The study found that the wide variation of products requires different working methods, which leads to a different time duration in both batch and unit levels. Moreover, the researchers have found that the seven factors examined have up to 50% influence on the time durations, thus the cost, when they're considered a group. The influence of every factor on the time duration does not exceed 17% at the highest. These findings have led the researchers to conclude that the accuracy is more reliable when multiple cost drivers are combined as a set in the cost accounting system instead of a single transaction-based one. In addition, they've concluded that the accuracy increases when actual-time data are being used to feed the system rather than the standard times.

One of the significant concerns around adopting the TD-ABC model is using the standard time instead of the actual time to record the activity duration. Using the standard times is a solution if the company doesn't integrate automatic data collection (ADC) tools with its accounting system. As mentioned earlier, the usage of standard time could make the model vulnerable to errors (Dejnega, 2011). Everaert et al. (2008) call for the future researchers to study the role of such technologies in feeding the TD-ABC model with actual time data. Bahr and Price (2016) have responded to this call by integrating the RFID technology into the TD-ABC model in case-study research. However, their research doesn't focus on how the TD-ABC cost information will differ in the two scenarios, namely when using actual versus standard time data. Instead, it mainly focuses on the applicability of the conjunction between the RFID and TD-ABC systems and how the first will impact the latter. Therefore, comparing actual and standard time data in the TD-ABC model is still an untapped research opportunity.

One of the apparent advantages of using the TD-ABC model in the supply chain settings is the possibility of developing one model that computes the operation costs under different capacity rates. Afonso and Santana (2016) have proved this feature by conducting case-study research on a distribution centre that performs two main processes: internal logistics and distribution. To implement those two processes, this distribution centre performs several activities using different resources to deliver a wide range of products from five different categories to the company's customers in different areas. Therefore, the researchers had to deal with this complexity in operation by developing a TD-ABC model that uses three different capacity rates. Using multiple rates instead of one is to adapt the model to the complex operating environment since each process requires different sets of resources. Afonso and Santana (2016) have found that this level of elaboration in capacity cost rates has helped to provide more reliable cost and profitability data for analysis, as well as insights into the unused capacity costs.

Focusing a review on the studies that have discussed the applications of the TD-ABC in 3PL and 4PL companies, reveals a few researches that have contributed to this area. Somapa et al. (2012) have looked at the application of the TD-ABC model in small logistics companies. A small 3PL company was selected as a case company to develop a TD-ABC model. This company provides warehousing and distribution services to its clients. However, the costs of the services offered were not well-calculated under the current accounting system, which relied on the period-cost methodology. Under this methodology, all costs and expenses within a certain period were combined and subtracted from the revenue. And then, the difference between those two numbers represents the profit or the loss. This methodology can't provide accurate information about each customer, service, channel, or other object's costs and profits. Therefore, the researchers have found that the application of the TD-ABC model is not only possible, but it's also helpful. However, the researchers have stated several difficulties when implementing the TD-ABC model for the case company. These difficulties are attributed to the firm's size, such as the lack of quantitative data, the problem of estimating times of some rare activities, and the allocation of joint costs. These findings open new avenues for future researchers to further explore those challenges and understand how TD-ABC developers can overcome them.

The second study that focuses on the adoption of the TD-ABC by 3PLs companies is (Ma, 2014). This study is similar to (Somapa et al., 2012) regarding the research aim. They both explore how the cost information will be modelled under the TD-ABC system for 3PL providers with no costing systems. Those companies relied on the financial accounting system instead. The case company selected in this research has three warehouses and five departments operating as main and supporting departments to the logistics activities. Therefore, the researcher has built the TD-

ABC model to capture all activities costs across those locations and departments. The TD-ABC model has helped provide more insightful cost and profit information by distinguishing between the profitable and non-profitable, or fewer, customers and services. Moreover, the researcher has found that this model can calculate the ideal capacity in the five departments. These findings help back decisionmakers with more reliable data.

A more recent study was conducted by (Danomah, 2021) to investigate the role of TD-ABC in a 4PL company. The researcher selected a logistics company that provides the procurement service to its African clients who purchases from Chinese manufacturers. The study aimed to develop a TD-ABC model that can capture the overhead cost assigned to the operation department at the case company. The model was designed following (Kaplan & Anderson, 2004) general guidelines. However, it seems the researcher used a mixture of the ABC and TD-ABC systems as he relied on the employee estimations for the process times in percentage. In addition, he didn't elaborate on the process steps and variations. Another major flaw in this study is that the researcher used the hours as a base for the CCR instead of the minutes. The TD-ABC is a minute-based system, as Kaplan and Anderson (2004) suggest. The researcher found that the TD-ABC system succeeded in diagnosing some flaws in the existing financial system in underestimation of the costs assigned to the operation department. In addition, the TD-ABC system discovered a high drain in productivity time, where 52% of the total overhead cost was assigned to unused capacity.

Conclusion

This chapter reviewed the most popular cost models reported in the literature. It can be inferred that each system has its strengths and weaknesses. The SC system has been featured with simplicity, but it is not suitable for environments with multiple departments and activities. On the other hand, the ABC system is preferred in complex organisations as it focuses primarily on activities. However, this system requires a vast database to include all activities and their variations, so it requires significant effort to maintain the system. In addition, it was flawed because it could not capture the idle capacity cost. Therefore, the TD-ABC system was innovated to overcome these flaws in both systems. Although this recent system's innovators claim that it's more capable of capturing the actual cost and is easier and faster to develop and maintain, other researchers claim that the TD-ABC system is also prone to significant drawbacks. This research investigates the TD-ABC system in a complex environment to evaluate its capability to capture the actual cost of integrated supply chain services. The next chapter discusses the methodology adopted by the researcher to implement this study.

Chapter 4 : The Research Methodology

Introduction

The previous two chapters review the two elements of this research's theoretical framework, the logistics management and the costing models. This chapter discusses how the researcher has designed this research using the case-study approach. Section 4.1 highlights the research paradigm that underpins this research's philosophy. Section 4.2 discusses the case-study research history, types, advantages, disadvantages, and more. In Section 4.3, the researcher explains how he designed his research using the mixed-method strategy, and in Section 4.4, he defines the means and strategies used to collect data. Finally, Section 4.5 sheds light on the research design quality.

4.1 The research paradigm

As an academic discipline, the business and management field has a short history compared with other ancient disciplines such as sociology and psychology. When this discipline emerged a century ago, researchers extracted their theoretical background from a blend of other well-established disciplines. This extraction from multiple resources has resulted in the diverse research philosophies and methodologies that someone can notice today in the discipline's research (Saunders et al., 2019).

This discipline has become a significant element of the social science body today. Researchers in this field, as in all other fields, conduct their research equipped with their beliefs and assumptions about the external world. Either consciously or not, the researchers make sets of ontological, epistemological, and axiological assumptions at every stage of the research about realities, knowledge, and values (Saunders et al., 2019). Consequently, these assumptions shape the research methodologies and approaches and eventually affect the outcomes. Epistemologically, researchers can adopt several paradigms to present their perspectives, including positivism, interpretivism, criticalism, and pragmatism. When a researcher adopts a specific research paradigm, the methodological aspects, such as the data collected, the research design, and the analysis method, will be shaped based on that paradigm adopted.

Considering the nature of this research which aims to understand the role of the TD-ABC model in the supply chain context, the researcher claims that the pragmatism perspective is the most relevant paradigm that should underpin this research's methodology. According to Wahyuni (2012), this paradigm adopts a unique principle where pragmatists start the research with a concentration on the research questions rather than the ontological, epistemological, and axiological questioning. This principle implies that the researchers can use a mixture of ontological and epistemological perspectives that helps to understand social phenomena. In addition, it implies they have more freedom to design their studies based on a blend of different quantitative and qualitative methods and data. As its proponents argue, the pragmatism research philosophy provides a compromise solution to avoid the long-lasting war between the quantitative and qualitative paradigms' advocates by adopting the mixed-method research approach (Feilzer, 2010). The need to profoundly investigate the role of the TD-ABC model in a complex environment such as the logistics industry demands an independent researcher who can select what works best to answer the research questions. Developing a new costing model, comparing two costing methodologies to explore the differences in the development process and outcomes, and exploring the reports' quality all require flexibility in selecting research design and data collection means, which the pragmatism paradigm can offer.

4.2 The case-study research

Introduction

Although the economics principles instruct management accounting research to help organisations fulfilling their objectives, Anderson and Widener (2006) argue that management accounting researchers should not neglect the social context of organisations in their research as this stance can offer a reasonable explanation for the observed practices. The direct interactions between researchers and organisations' members in natural settings can help clarify the rationale of practices inside organisations. This research has considered this perspective by adopting the case-study strategy to substantially engage in the field with the case organisation's members for a considerable time. This strategy is decisive for understanding events in their contexts and capturing their complexity (Stake, 1995), and "to understand the selected case or cases in depth" (Bryman, 2016, p. 10). In this research, there are three main objectives. The first is to shed light on integrated supply chain services and develop a simulated TD-ABC system accordingly. Secondly, it is to develop a simulated ABC system to compare it with the TD-ABC model in terms of the development process and outcomes. Finally, it is to compare the cost and profitability reports generated from the TD-ABC systems with those generated from the P&L statement and the SC system. Achieving these objectives requires a robust research strategy that helps collect, analyse, and interpret quantitative and qualitative data from multiple sources. The case-study strategy is effectively illustrative in similar studies that discuss the role of the TD-ABC methodology in modelling the logistics costs (Everaert et al., 2008; Gervais et al., 2010; Kim et al., 2016; Ma, 2014; Somapa et al., 2012). Therefore, this research adheres to the same strategy for the aforementioned justifications.

The history of case research

The history of adopting the case-study approach goes back to ancient times when humans implemented it for methodological exploration. However, the contemporary history of case research strategy has emerged in recent qualitative inquiries where historical examples of this research strategy have been found in the biography of Charles Darwin (Harrison et al., 2017). During this contemporary history, the case studies research has passed two distinctive stages as Figure 4-1, which was developed by (Johansson, 2007), summaries. The first stage of this history was associated with the profound investigations of individuals and cultures conducted using this research strategy by the Chicago School of Sociology in the early twentieth century. However, that stage did not last long. With the rise and dominance of logical positivism between the 1940s and 1970s, most social science researchers leaned towards quantitative-based research designs such as experiments and surveys. This trend was attributed to the scepticism and criticism surrounding qualitative studies as they lack generalisation and limited validity (Harrison et al., 2017). Qualitative studies, especially the case research designs, have developed dramatically in the last fifty years when integrated with the quantitative data analysis methods in the grounded-theory-based research (Johansson, 2007). Consequently, scholars from multiple disciplines have renewed their confidence and interest in adopting this research strategy as a rigorous alternative to the pure quantitative-based designs that have been dominant since the late 1940s (Harrison et al., 2017).

The definition of case research

The multidisciplinary origin of case research has resulted in various definitions and descriptions of this strategy in literature, which may create confusion for the researchers who attempt to understand it (Harrison et al., 2017). According to Vanwynsberghe and Khan (2007), more than 25 definitions of case research have been found in literature over the past three decades. Undoubtedly, this number has significantly increased recently. As a result, this wide range of definitions has created a sort of disagreement among researchers about what the term case research means. In other words, is it a methodology, method, or design? Vanwynsberghe and Khan (2007) claim that scholars have an evident misconception in interpreting case research as a research methodology, method, or design. According to the authors, these terms are not relevant and represent the real meaning of case research. Hyett et al. (2014) and Harrison et al. (2017) emphasise this misconception and attribute it to the researchers' interchangeable usage of the terms methodology and method. They claim that some researchers interchange these terms because they conduct research without sufficient consideration for the underpinning epistemology and historical tradition (Hyett et al., 2014) and definition clarity (Harrison et al., 2017). Miles (2015) states that the little consensus about the case research term is due to the under-conceptualisation and the complex practice of such research. This disagreement among scholars about the theoretical meaning of the case research term should not prevent us from considering some best efforts that have contributed to knowledge with guiding definitions for the researchers.

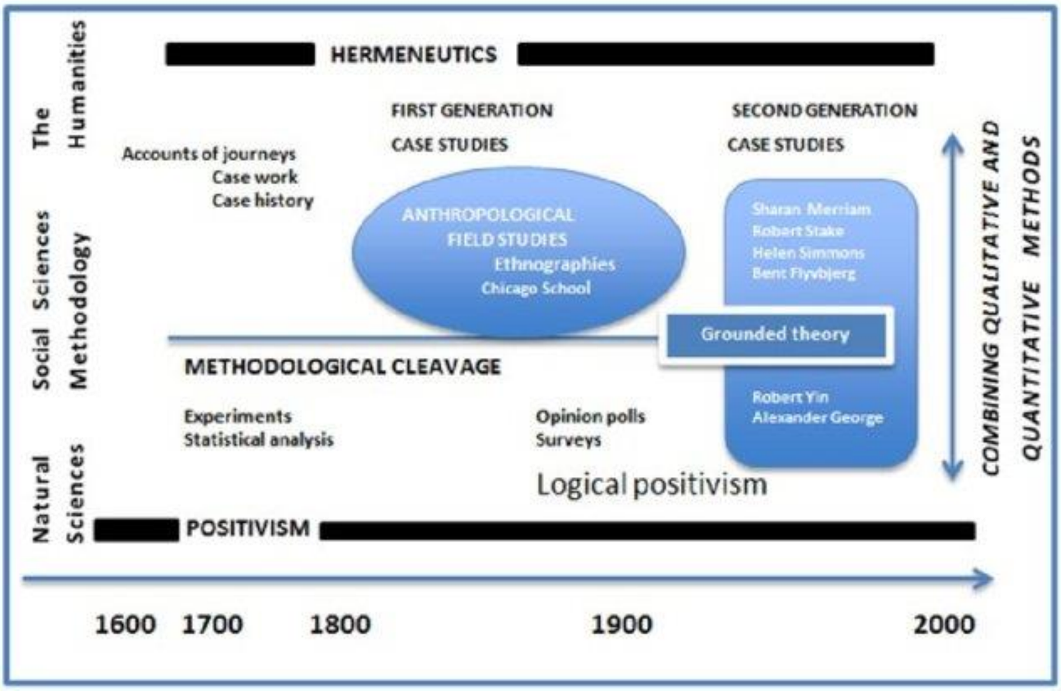

Figure 4-1: Case-study research development stages. (Johansson, 2007)

According to Harrison et al. (2017), the most cited definitions found in the literature come from three prominent works: Stake (1995), Yin (2014), and Merriam (2009). These three scholars have agreed that the focus of case research is the deep investigation of a particular case (or cases) studied to a predetermined extent and its natural settings. However, unique propositions distinguish one work from another among the three definitions. For example, Yin (2014) defines case research, from a technical perspective, as a research inquiry that deals with two parts: the context in which a case is being studied and the data sources that should be captured during the research. He claims that case research is empirical-based research that deals with a contemporary phenomenon in natural settings where the boundaries between this phenomenon and settings are not obvious. In addition, he states that this strategy implies that the researchers should collect encompassing data from all available sources to validate the research’s findings. Stake (1995), on the other hand, shows less emphasis on how the case research should be implemented technically. Instead, it focuses on the case itself as a unit of analysis. He defines case research as "the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances." (Stake, 1995, p. xi). Finally, Merriam (2009) goes beyond (Stake, 1995) and includes the products of a case research study when she describes it as "an in-depth description and analysis of a bounded system." (Merriam, 2009, p. 40).

The three aforementioned contributions are not the only sources defining the case-study research. The literature is rich with other informative definitions, such as those cited in (Bryman, 2016; Flyvbjerg, 2001; Gerring, 2004) and more. However, this research will rely on (Yin, 2003) definition as it aligns with the researcher's perspective on what he means by the case study in this research. Yin (2003) considers the case study as a research strategy. There are several other research strategies, including surveys and experiments. As defined by (Johannesson & Perjons, 2014, p. 39), the research strategy is "an overall plan for conducting a research study."

The research strategy is associated with the high level that guides the researcher's planning, execution, and monitoring of the research steps. Accordingly, the term strategy will be adopted in this research. Design and method are the other most confusing terms that are interchangeably used to describe case research. The research design, elaborated in the following sections, refers to the steps a researcher follows to perform both data collection and data analysis techniques. In mixed-methods studies, for example, there are four main designs: triangulation, embedded, explanatory, and exploratory (Creswell & Plano Clark, 2007). Finally, the research methods refer to the tools and methods used for data collection and analysis. For example, interviews, direct observations, and document review are data collection methods, while content analysis, descriptive statistics analysis, and comparative analysis are data analysis techniques.

Types of case research

Case-study research can vary depending on the dimensions examined. From the dimension of the study's objectives, Yin (2018) claims that the case study can be used for at least four different applications: explanatory, descriptive, illustrative, and enlightening research inquiries. According to Yin, RK (2018), explanatory case studies are the most common type. Researchers use it to explain complicated causal links in the real world which can't be explained by other research strategies such as experiments and surveys. On the other hand, descriptive studies aim to draw a comprehensive understanding of a detailed phenomenon. This research type is also referred to as holistic, interpretive, intrinsic, and the study of commonalities (Ho et al., 2007). Thirdly, case research can be adopted for illustrative purposes. The illustrative case studies take the descriptive mode as well. However, such studies aim to depict particular events in their settings (Yin, 2018). Finally, some researchers adopt the case-study strategy to enlighten readers about specific phenomena where the literature has no clear outcomes.

This study of the TD-ABC role in the logistics industry takes the explanatory style where the researcher aims to explore the integrated logistics services, the TD-ABC model's role in capturing the actual cost of these services, and the differences between the TD-ABC and ABC models in generating the cost and profitability reports.

Another considerable dimension in differentiating the case-study types is the number of cases. Some studies use a single case, while others use multiple cases. Gustafsson (2017) reviewed two groups of twenty single and multiple case studies (ten each) and found some similarities and differences among these studies and the advantages and disadvantages associated with each group. Therefore, he recommends determining the best choice to adopt, whether a single case or multiple cases, depends on two factors. First, the context in which a study is being implemented should be considered by researchers as it plays a crucial role in this decision. Using a multiple-cases design, for example, is powerful when the comparison across cases adds value to the research findings. Secondly, the determination of the number of cases in a study "depends upon how much is known and how much new information the cases bring and how much is known." (Gustafsson, 2017, p. 4). For instance, a single-case study is recommended when a researcher aims to investigate the existence of a phenomenon more deeply and carefully. This study empowers researchers to describe the case and provide insightful findings richly. Yin (2003) outlines five rationales for selecting the single-case design in social research, including the case representativeness of the typical objects. For example, a single company might be selected alone as the research case if it represents the average company in its industry. This research adheres to this rationale by selecting a single yet representative logistics company. More details about this selection will be discussed in the following sections.

Case study strengths, limitations, and objections

Each research strategy complements the strengths and limitations that researchers must know in advance. In one strategy, the strengths are solutions for another strategy's weaknesses and vice versa. The case study is not an exception. Bennett and George (2005) identify four strengths that excel in the case study as a powerful strategy for developing theories. They claim that the case-study strategy can lead to high conceptual validity, strong hypotheses, practical examination of causal mechanisms, and robust solutions for casual complexity. Vanwynsberghe and Khan (2007) determine seven standard features in a prototypical case study. From these features, we can summarise the strengths of the case-study strategy in the following points:

- Providing contextual details that give the reader the sense of being there.
- Enhancing the research effectiveness as it investigates a small number of participants.

- Studying phenomena in their natural settings where there is little control over the object studied.
- Exploring new working hypotheses and learning new lessons while collecting data.
- Moreover, finally, converging multiple sources of data and inquiry lines in one study leads to more accurate and compelling findings.

The advantages mentioned above of the case study are valid when the research is well designed. Nevertheless, researchers must acknowledge that some limitations and criticisms of this strategy have been found and reported in the literature that the researchers must be aware of. According to (Yin, 2018), some of these criticisms are attributed to the lack of trust in the researcher’s procedures when designing and collecting the research evidence. Researchers who follow this strategy might find themselves biased as they may have preconceived notions about the case. Thus, they will be challenged to design the research procedures in a manner that is free of bias. Otherwise, their preconceived notions will lead the research design towards pre-desired directions. Flyvbjerg (2001) disagrees that case-study researchers tend to be biased in confirming their pre-set opinions toward the case. Conversely, he argues that since the case study involves intensive evidence collection about the phenomena investigated, the researchers are more likely to be biased toward falsifying their prior perceptions instead of confirmation.

Case-study researchers also might be criticised if there is prior knowledge between the case and researcher. This type of bias is called the case selection bias (Starman, 2013). Starman (2013) argues that prior knowledge between the researcher and the case is an advantage rather than a disadvantage. The author claims that selecting a case based on prior knowledge leads to better results as it enables the researcher to develop a more substantial theoretical base for the research and allows him to test theories more rigorously. Besides, he claims that the shortcomings of selection bias can be eliminated using methodological provisions such as diligence and consistency when describing the research procedures in detail. Such a detailed description of the research process will add more reliability to the case research’s findings.

Another discomfort with the case research strategy comes from the notion that this type of study cannot be generalised to a broader range. Studying a single case or even a few numbers of cases is not adequate to make the results applicable to other contexts. Therefore, some researchers are sceptical that “the single-case study cannot contribute to scientific development” (Flyvbjerg, 2006, p. 219). Yin (2018), however, argues that before we accept or reject this limitation, we must distinguish between two types of generalisation: statistical and analytic generalisation- although the term statistical seems less relevant to the qualitative research than empirical (Flick et al., 2014).

Statistical generalisation refers to the conclusion reached about a specific universe based on evidence collected from a sample representing that universe. This generalisation is common when doing surveys or data archive analysis and is less relevant when doing a case study. Therefore, it is not acceptable statistically to generalise a case study's findings since the single- or multi-cases are not sampling units, and they are not adequate to represent their larger population. The second type of generalisation proposed by (Yin, 2018) is the analytic generalisation, in which a case study uses existing theory as a template to support its empirical findings or compare them with other cases. In this sense, the case study is an excellent strategy to generalise theoretical propositions but not statistical results. Finally, Flick et al. (2014) suggest a third type of generalisation that the case study is valid for. This type is not associated with the research findings or interpretations yet with the case-to-case transferability. The authors claim that the case study can be generalised by the reader instead of the researcher by transferring the knowledge from an existing study to a new one.

Criticism of the lack of generalisability of case studies has led to another common misunderstanding: the case study is not a robust strategy for building theories and testing hypotheses (Miles, 2015). People who argue this believe that this strategy is a valuable tool for generating hypotheses in the first research stage. Flyvbjerg (2006), however, disagrees with this notion. He claims that "The case study is useful for both generating and testing of hypotheses but is not limited to these research activities alone" (Flyvbjerg, 2006, p. 229). His disagreement with this misconception stems from his conviction that the case study is valuable at all research stages and a powerful theory generator as long as the researcher has chosen a critical case for his study. In other words, he believes that case selection is a crucial step in the overall research procedure. When a researcher selects a critical case carefully and based on objective criteria, the researcher will have a chance to encounter rich information that allows him to deduce new theories. The purpose of selecting a critical case is "to achieve information that permits logical deductions of the type." where "if this is (not) valid for this case, then it applies to all (no) cases." (Flyvbjerg, 2006, p. 230). In contrast, the random or average case might be a good selection for generalisation purposes yet not for theory development and hypothesis testing as they are not rich in information. Such cases fail to clarify the causes behind a particular problem, and they perform reasonably in describing the symptoms of that problem.

Some people believe that the case study is always associated with qualitative data, so someone may criticise this strategy because they feel uncomfortable with the qualitative data collection and analysis procedures (Yin, 2018). Conversely to the numeric one, the narrative data are not easy to collect, analyse, and interpret as they are perceived to be less robust than the quantitative-based studies (Yin, 2018). Thus, some critics find it a source of shortcomings in the case study’s findings. However, this statement is not always correct where the case-study strategy is not necessarily associated with qualitative data. For example, this research uses the mixed-method approach where the case-study strategy represents the qualitative side, yet with a heavy reliance on numeric data, such as financial and operational numbers. Therefore, this criticism is not necessarily valid. Besides, it is also appropriate to defend the quality of qualitative data as a source of evidence.

Flyvbjerg (2006) states that narratives are powerful when complexities and contradictions cover the phenomena studied. In such situations, narratives can uncover the evidence in their real world in a way that would not happen otherwise. Besides, the author claims that the thick and hard-to-summarise narrative is not an issue. Instead, it signifies that the study deals with an intricate problem that needs a rich explanation. Flick (2018) suggests that with the remarkable developments of qualitative research that have been occurring since its emergence, different high-quality research programs have contributed to various fields dominated by other research approaches. That means that qualitative data-based research can contribute well to any relevant discipline. However, we must distinguish between good-quality research and a weak one, on a single basis, not an entire approach.

4.3 The research design

Every single research aims to solve a particular problem or answer questions using sets of means such as data collection and analysis tools. However, to achieve this aim, the researcher must know the best research design that employs those tools to connect the research questions with the research conclusions. Yin (2003) defines the research design as “A logical plan for getting from here to there, where here may be defined as the set of questions to be addressed, and there is some set of conclusions about these questions.” (Yin, 2003, p. 20). He also asserts that there are several significant steps between the here and there points, including the collection and analysis of relevant data. Accordingly, every empirical research must have a research design, whether explicitly or implicitly discussed (Yin, 2003).

In the case study, the are five essentials in the research design (Yin, 2003). First, the research questions. They are most likely to be how and why questions. The case study is a powerful strategy to solve such questions as it supports the researcher's profoundly investigating of the evidence to find the research answers (Rowley, 2002). The second component of the case-study research design is the study propositions. The how and why questions can be broad and misleading if they’re not directed to specific research propositions. These propositions help researchers move in the right direction when collecting data. For example, if case research aims to study why a specific organisation decided to collaborate with other organisations, the researcher must first identify and study the propositions that may lead organisations toward collaboration, such as the mutual benefits. This step will facilitate the data collection procedures and ensure that the research questions are not broad, and thus hard to answer.

The case selected is considered the third component of any case-study design, according to Yin (2003). The researcher needs to address this component in two steps – defining the case and then bounding the case. While defining the case means identifying the appropriate person, community, event, or entity that will be studied, the bounding step refers to determining the scope of data collection from that case, whether in terms of participants or time boundaries (Yin, 2003). To illustrate, a researcher may select a specific community as the research case. This selection is broad unless the researcher defines who will participate from that community and the time period this study covers. Setting such boundaries should tighten the connection between the research questions and conclusions (Yin, 2003).

Linking data to the research propositions comes in fourth place when designing case research. This linkage can be done using analytical techniques and steps such as pattern matching and explanation building. The researcher should know the best technique that suits the case study. Finally, the case design should explain why this case's findings are significant. Unlike the quantitative studies that present their findings' strengths statistically, Yin (2003) states that the case study's findings should be explained and advocated by the researcher by exposing the alternate studies' flaws. This strategy is an effective way to convince readers of the study's firm conclusions. Therefore, the researcher must consider this component in their research design by considering some alternate studies in advance.

Mixed methods design

Studying the integrated supply chain management processes and designing an appropriate costing model requires a deep investigation using multiple quantitative and qualitative techniques and data. Researchers who follow this blended approach could strengthen their findings by exploiting the advantages and avoiding the limitations of the quantitative and qualitative approaches if they were used alone.

Onwuegbuzie and Johnson (2004) claim that mixed-methods research can be classified into several typologies based on the dimension considered when a researcher plans mixed-methods research. For example, one may consider adopting quantitative and qualitative approaches across or within the research stages. In this case, the researcher can label this research as a mixed-methods research from the research design dimension. On the other hand, another researcher can use one research design (e.g. questionnaire), yet with the collection of both quantitative and qualitative data (e.g. rating scales along with open-ended questions). Therefore, it's also mixed-methods research from the data dimension. Onwuegbuzie and Johnson (2004) argue that pragmatists must be creative in designing their research and not be limited to what has been written in literature. A new mixed-methods design can be innovated by a researcher depending on the research's needs. As mentioned earlier, this flexibility in pragmatic research allows the researchers to focus on finding the research answers freely.

This research follows the mixed-methods approach, where quantitative and qualitative data collection and analysis tools are equally necessary. Creswell and Plano Clark (2007) claims that nearly forty mixed-method designs have been found in the literature. Once a researcher follows the mixed-methods approach, his/her next task is to select the best suitable research design from that wide range (Creswell, 2009). However, since this task is overwhelming with this vast number of designs, Creswell (2009) has identified the similarities among those classifications in an attempt to group them into only four major designs. He claims that the four major designs embed significant variations within each type; thus, it makes the design selection easier for researchers. These designs are the triangulation design, the embedded design, the explanatory design, and the exploratory design.

The triangulation design

This is the most common design used for mixing quantitative and qualitative methods, where it assists researchers in overcoming the weaknesses and utilising each method's strengths if adopted individually (Creswell (2009). By choosing this design, the researchers intend to compare, contrast, validate, or expand results using different methods. In contrast to some other designs, the triangulation design is a single-phase design where the researchers collect and analyse the mixed methods concurrently and with equal weight in an attempt to merge two data sets for one overall interpretation (Creswell, 2009). However, this interpretation could be reached in several ways. Creswell (2009) identifies four variant models that fall under this design, which researchers can follow, and they are: 1the convergence model, the data transformation model, the validating quantitative data model, and the multi-level model. While the first two models are used to merge different data sets either during interpretation (Model 1) or during analysis (Model 2), Model 3 is used to enhance results using surveys, and Model 4 is used by researchers to examine different levels of analysis (Creswell, 2009).

Adopting the triangulation design implies several strengths as well as limitations. Creswell (2009) states that this design makes intuitive sense, where researchers who are less familiar with the mixed methods often choose this design. He means that this design is the easiest path towards mixed-methods research. The author also claims that the triangulation design is efficient as it combines both quantitative and qualitative data at the same time and weight. Last but not least, Creswell (2009) suggests that this design can create powerful harmony between the research team where individuals from different research backgrounds can unite; thus, they will be eligible to produce valid and reliable outcomes.

On the other hand, Creswell (2009) points out several challenges associated with the triangulation design overall and with some of its models. Overall, he states that this design can be overwhelming as it requires concurrent data collection and analysis from different sources. He also argues that some researchers will face challenges if they find inconsistencies between the quantitative and qualitative findings. Although these two points seem challenging, Creswell (2009) suggests some solutions that can help researchers to overcome them. Therefore, researchers who intend to adopt this design should be aware of those challenges and suggest solutions for smooth research implementation and contributing outcomes.

As mentioned above, this research adopts the case-study strategy to understand the logistics activities processes and to build the TD-ABC model accordingly. This implies that the research design needs to be built in a way that allows the collection of both quantitative and qualitative data. Therefore, this study employs three appropriate means that best serve the selected methodology: semi-structured interviews, direct observations, and document reviews. This approach helps the researcher avoid quantitative and qualitative data defects when used separately (Onwuegbuzie & Leech, 2005). Additionally, it provides a more decisive conclusion by "convergence and corroboration of findings" (Onwuegbuzie & Leech, 2005, p. 21). The cost data, general ledger information, and operation logbooks were collected as essential data sources. However, they can't explain phenomena independently without qualitative data, which are needed to justify and explain those phenomena. On the other hand, observing people while they perform activities and interviewing the managers and staff are not necessarily meaningful when they are stand-alone. They need to be backed by some supportive and reliable numbers. Therefore, combining those quantitative and qualitative data should result in explanatory and reliable results that can strengthen the research outcomes.

4.4 Data Collection Methods

Semi-structured Interviews

Semi-structured interviews were held with a number of top- and mid-level managers at the case company to gain an in-depth explanation of the services, customers, processes, and more. This method is appropriate for finding out answers to the why questions rather than how much or how many questions (Fylan, 2005). I've chosen the semi-structured interviews because they allow more elaborative answers from participants and give both the researcher and the participants the freedom to ask, explain, and move in different directions. During this research, the researcher interviewed the general manager, operation manager, transportation manager, supply chain supervisor, maintenance team manager, and treasury manager to understand the company's whole picture and the operation cycle before starting the observation sessions, and here are the main questions asked to the interviewees:

- Can you please brief me about your company's services and activities?
- How do you calculate the cost of operation in your company?
- How does the company price its services?
- How do you describe the flow of the (service name) process?
- Can you please tell me about your customer segments?

These interviews were recorded with the consent of the participants. The purpose of these interviews is to understand better how the company works and how the operation cycle functions at the case company. Interestingly, the answers were confirmed or revised when the direct-observation sessions took place later. The observations also were backed by occasional interviews with the operation teams, who can provide more detailed information on what, how, and why they perform each task.

Direct Observation

The best way to deeply understand the logistics operation at the LSP is to observe its activities directly. The detailed actions and information about those activities must be adequately observed and written down by the researcher before moving towards the analysis (Gervais et al., 2010; Gonzalez et al., 2017; Kim et al., 2016; Somapa et al., 2012). The data captured using this technique encompasses the operation processes, durations, the resources needed, the causes of variation in resource consumption, and the opportunities that can be utilised to enhance efficiency. In addition, this method was adopted, as mentioned above, to confirm or revise the answers of the top-level managers and the operation teams for the interview questions.

The methodology of the TD-ABC system depends on inherited formulas that calculate the costs of performing activities based on two factors: the duration needed to implement the activity and the costs of the resources supplied to perform it. Thus, it's essential to determine the reasonable duration (the first factor) for each task so we can standardise it and build the TD-ABC formulas based on it. The averaging technique was used to assist the researcher in calculating the time needed to perform each activity more accurately than relying on one-observation results. This technique helps eliminate fluctuations in the time durations resulting from unplanned actions or interruptions. Observing the activities and their steps must be repeated adequately to calculate the average durations per task. And to enhance the quality of this technique's results, the observation sessions must be distributed randomly to reflect the reality of the operation performance under different circumstances.

Document Reviews

The document review technique was used primarily to extract cost and operational data. Therefore, after finishing the observational sessions and understanding the logistics services cycles, the financial and operational transactions history for the first quarter of 2021 was extracted thoroughly from the company's IT system. As these records were massive and contained tens of thousands of operational transactions, the researcher selected one customer's record for the cost model construction. From the operational side, the received shipments, processed orders, deliveries, and other operational transaction records for that selected customer were extracted for model construction purposes. Financially, the general ledger of the case company was an important document to review and use for the TD-ABC model. Therefore, the Q1-2021 financial transactions were extracted and reviewed entirely. Other supporting documents were needed for review and usage in the analysis phase, such as the electricity consumption report, which was prepared by the maintenance team at the case company, and the employee and workers records, which were provided by HR.

4.5 The case company:

The selection criteria

This research aims to develop a TD-ABC model that serves the supply chain companies in calculating the cost of providing integrated 4PL services accurately. Therefore, the researcher had set two criteria to nominate the case company of this research. First, the case company should provide a wide range of integrated supply chain services beyond standard warehousing and distribution activities. Services such as procurement management, demand planning, claims management, and inbound transportation are untapped areas that have not been discussed in similar research. The second criterion is the company's operational excellence. The case company must follow the supply chain and logistics industry best practices. Selecting one that doesn't meet high-quality operation standards means this research results can't be generalised elsewhere.

The case company

A medium-sized Saudi-based logistics company was selected to be the case company in this research. For the confidentiality of its financial data, the company's real name is disguised as Speedy. The reason behind choosing Saudi Arabia as a geographic scope of this research is that the Saudi Government sponsors the researcher, so he was supported by the government to gain the resources and access needed. The researcher reached Speedy through one of his friends who used to work there, who introduced me to Speedy's GM, who welcomed the idea. Speedy employs around 130 people in its five locations in Dammam, Riyadh, and Jeddah cities, and it owns around 50 trucks to serve its customers nationwide.

Interestingly, Speedy's business model only focuses on serving companies that work in the food industry. Therefore, in addition to providing warehousing services in the typical ambient warehouses, Speedy has chilled and frozen warehouses to serve its clients who have chilled and frozen products. The company provides demand planning, procurement, inbound transportation, warehousing, orders fulfilment, outbound transportation, and some added-value services such as labelling and technical services and information logistics services.

Speedy is one of seven sister companies that work under the umbrella of one holding company. The other six sister companies work in multiple fields, such as trading, manufacturing, logistics, construction, and catering services. All these sister companies share and pay for sharing resources the holding company provides, such as IT, HR, and legal services. In other words, the holding company acts as a parent company that serves the seven operating child companies with back-office services. In contrast, each child company has its own general manager who operates his company to contribute to the bottom line. That means each general manager has the full authority to make high-level decisions, hire resources, make deals, control products or services, etc. Each individual company, consequently, has its own operation and financial systems that monitor its goals and performance.

As mentioned earlier, Speedy has multiple locations around Saudi Arabia. The data was collected from the head office and its central warehouse. Both sites are located in Dammam City. The two reasons behind choosing these locations are: to have the opportunity to meet the executive-level managers for the interviews' purposes and because all 4PL services are being managed in the central warehouse in Dammam City. In Dammam City alone, Speedy has two locations where one of them is rented from the holding company and attached to the head office, and the second is rented from a third party that provides monthly-based warehousing services. In Riyadh City, there are also two locations; one is rented from the holding company, and the other is rented from a third party. In Jeddah City, only one location is rented from the holding company. The distribution of these locations is planned to cover all 13 Saudi regions with the optimal efficiency and cost equation. Each location has the best solutions, equipment, and tools to provide high-standard warehousing services for ambient, chilled, and frozen products.

In Q1-2021, Speedy's revenue was around SR15 million, serving around 15 clients by providing a wide range of supply chain and logistics services. The services are tailored based on the customers' needs. Some customers have contracts with Speedy for 2PL services, such as warehousing only. On the other hand, some customers demand 3PL services to utilise Speedy's best-in-class warehouses and fleet for storing and distributing their products nationwide. A few other customers go beyond the 2PL and 3PL services by demanding more advanced supply chain services such as procurement management, demand planning, insurance, and costing, which we call 4PL. This last category is the focus of the researcher as it gives a more depth analysis of the role of the TD-ABC model in supply chain management.

The second criterion for the selection of the case company was the quality and the high-standard procedures set for the operation management. Speedy has been known for its best practices in receiving, storing, and distribution management. This reputation has resulted in good relationships with well-known international brands that have decided to outsource their logistics operation to Speedy. Speedy has been awarded top-notch certificates in the quality management arena by third parties who implement restricted criteria for inspection and assurance. For example, it has been certified by the global supply chain assurance organisation BRCGS, for it complies with the global standards for storage and distribution. This certificate assures the excellence of the operational process at Speedy to ensure safe storage and transportation of the food. In addition, Speedy has successfully passed the Distributor Quality Management Program (DQMP), which is designed by MacDonald's to ensure safe and high-quality operations for food storage and deliveries.

Although the parent company uses the ABC system to calculate and allocate the overhead costs to its seven operating companies, Speedy, as a subsidiary, does not employ any advanced costing system for its operational and fiancial activities. Instead, it depends on the P&L as the primary source of cost and profit information. In addition, Speedy's management uses Excel spreadsheets to allocate the overhead costs to clients following the SC methodology and using the number of pallets as the sole cost driver. Accordingly, it aggregates all overhead costs and divides them into the total capacity of pallets. This results in the cost per pallet, which is called the overhead cost rate. Accordingly, if a customer had 100 pallets the previous month, and the overhead rate was SAR 15, the allocated overhead cost to that customer was SAR 1,500. This lack of advanced costing in the case company necessitated the researcher to construct both TD-ABC and ABC models using Excel spreadsheets. The models, then, were limited to a short duration to manage the huge financial and operational data extracted from the company's ERP.

The Case Customer

As this research scope focuses on the cost of integrated supply chain services, the researcher had to select a case customer who buys 4PL services from Speedy. At Speedy, there were tens of clients who used Speedy's 3PLs services; there were only two clients who used the 4PLs services (integrated supply chain). The selection decision between the two 4PLs clients was based on the business model. Client A is a relatively small chain of restaurants with more than 70 outlets globally and 14 in Saudi Arabia. This company produces most of its raw materials in its own factories and then stores them in distribution centres worldwide before they get delivered to restaurants. It deals with Speedy to store and distribute those materials to the branches in Saudi Arabia. Along with the storing and distribution services, Speedy provides other supply chain services for that client, such as planning and procurement for other materials and products they import from overseas.

Client B, on the other hand, is another chain of restaurants, but it's on an enormous level globally and a minor level locally. This client has more than 1700 restaurants worldwide and only 7 in Saudi Arabia (as of Q1-2021). This company doesn't have any manufacturing facility, so it buys its raw materials and final products from multiple vendors around the world. For this research, this company will be named "Hummy" as a disguised name for its data protection. Hummy deals with Speedy as a full supply chain services provider. Speedy plans, buys, imports, stores, and distributes all products that Hummy's locations in Saudi Arabia need. In other meaning, Speedy acts as a supply chain department for Hummy in Saudi Arabia.

The business contract between Hummy and Speedy is unique. Although Speedy provides a wide range of integrated supply chain services to Hummy's seven restaurants in Saudi Arabia, Hummy Corporate doesn't pay for these services directly. Instead, it pays against the cost of materials delivered to the restaurants plus a predetermined mark-up. This pricing model required an arrangement of OBA to be in place between the two parties. Accordingly, Speedy and Hummy agreed to share the cost of materials that Speedy buys for Hummy along with the landed cost, such as customs clearance, customs duty, inbound transportation, etc. On top of these costs, Hummy has to pay a certain percentage as a profit margin to Speedy. This margin allows Speedy to cover its overhead costs, such as rent, salaries, electricity, trucks, etc. Recently, Hummy's management started to negotiate with Speedy to reduce this mark-up, according to Speedy's general manager. The researcher has found this interesting to explore the actual cost and profit under the TD-ABC system. In addition, he found that selecting Hummy as a case customer is more feasible given the research's resource constraints (e.g. time) as it has fewer branches than customer A. Another reason behind the selection of Hummy as a case customer is that Hummy deals with tens of local and global vendors that Speedy should work with, which is the contrast to customer A's situation that produces most of its products and materials in-house. This distinction provides the researcher with an opportunity to delve deeper into various areas in the supply chain, especially those related to the procurement activity, while designing the costing model that captures all activities and tasks along the chain.

4.6 Research data and design quality

In research, one of the main issues that concerns both researcher and the reader is the validity and reliability of the research outcomes. In quantitative studies, this concern is less problematic than in qualitative research as they can be validated by relying on straightforward standardised measures. However, in case-study research, the researchers should take longer to reach a reasonable level of trust in the research data and design quality. Yin (2018) suggests four tests that can deal with this concern effectively: construct validity, external validity, internal validity, and reliability. Under these tests, multiple tactics can be implemented in different stages of the case-study research. However, they're not all appropriate for any case-study-based research. For example, the internal validity test is suitable for experimental and quasi-experimental research but not for descriptive or exploratory studies (Yin, 2018). The researcher, therefore, must be aware of the appropriate tests that suit his research's nature.

This research is exploratory and empirical in its nature. It aims to discover the rules of the TD-ABC model in integrated supply chain management. According to (Yin, 2018) suggestion, this research's quality can be tested through three main tests: construct validity, external validity, and reliability. The researcher followed several tactics to ensure a high-quality research design and data that serve the aim of this research.

Construct validity

One of the most advantageous when adapting the case-study strategy is the ability to use multiple evidence sources (Yin, 2018). Researchers have the power of triangulation that helps overcome the defects found in each research method. Although the triangulation strategy has four different types, according to (Patton, 2014), this research uses the first type, which is the use of multiple methods to collect data. Some data were collected using more than one means for two reasons. First, to collect more data or to find answers for missing parts (e.g. the business model). Second, to validate what has been collected, especially the processes and durations, during the field observation. This validation step was done at the end of the data collection journey. The researcher met the department managers two times. The first one was at the beginning of the journey and was for discovery purposes. The second one was after the completion of the field observation. The purpose of the second interview was to show them the results of the observations. The steps and durations were presented in diagrams for more clarification. The participants had a chance to review these diagrams before giving feedback. Participants sometimes agreed and confirmed the steps and durations, partially or entirely. In other cases, the department managers showed their different thoughts. The main reason behind this difference between the managers and the researcher on the processes or durations diagrams is that managers usually speak from their previous experience based on old observations that may not reflect the new reality in the operations field.

Therefore, the researcher had to decide which one he should consider for analysis, the manager's feedback or his own observations. He decided that if the difference was related to the process, activities, or steps, the participant's opinion overwrites the researcher's results. This decision is justified because the researcher assumes he missed those steps on the operation floor. On the other hand, if the difference between the researcher and the department manager was related to the durations, the researcher's results remain unchanged as they were counted and averaged recently. The duration data need fresh collection from the floor. The managers' feedback on durations is less accurate since they're not practising these activities any more. The same with the standard operating procedure (SOP) review. When the researcher finds some steps in the SOP document that he didn't observe, he deals with them similarly. If he's sure that workers are not doing that step any more, he will not rely on the SOP document as it's not valid anymore. However, if he finds that some steps were missed in his observations and finds relevant data in the SOP document, he will add them to complete the entire picture. In such cases, these steps' durations were only taken from the managers' interviews. gnus

External validity

External validity refers to the level where the study's results can be generalised and not only limited to the immediate research context. One of the significant criticisms associated with case study research is the lack of generalisability (Ellram, 1996). However, Yin (2018) argues that we should distinguish between statistical and analytic generalisability. While the former refers to the number of participants selected for the study, the latter defines generalisability as the ability to generate similar results if new studies were conducted under similar settings and designs. In other words, analytic generalisation means expanding theories and replicating the research design regardless of the number of participants studied in one research as long as the study is well structured. Another argument from (Yin, 2018) is whether the form of the research question(s) plays a significant role in making generalisable results. Case studies are primarily designed to seek answers to how and why questions. That approach allows researchers to rely on appropriate theories as the foundation of their research, which leads to achieving the analytic generalisation, thus the external validity. Other case studies, however, that strive to answer the what questions are merely documenting tools that aim to study social trends in limited populations (e.g. neighbourhoods or organisations.) Such studies, according to Yin, RK (2018) fail to generate generalisable outcomes. They might serve the research's objectives better when they use other methods.

Reliability

Reliability in research refers to the notion that the research's outcomes are free of random errors as they were generated following rigorous research design, and other researchers could achieve these outcomes again if they followed the same design (Gibbert et al., 2008). In other words, we can assess the reliability of any research by replicating the research following the same procedures and using the same data collected to reach the same original study's findings. This notion leads us to an important question: How can the researcher facilitate the assessment of his research reliability? Gibbert et al. (2008) suggest that transparency is the key to achieving this goal. Researchers need to be careful and transparent in their documentation and research procedures. Therefore, researchers may find it helpful to produce so-called case study protocol and case-study database. These two products suggested by (Gibbert et al., 2008) are powerful means to assess the research's reliability. While the case study protocol refers to the detailed procedures and guidance followed in the case-study research, the case study database is the bank of evidence collected during the research in the form of notes, documents, and narratives (Gibbert et al., 2008). With the existence of those two tools, new investigators can fairly judge the research's reliability.

In this research, the researcher follows this ideal practice by specifying a chapter that discusses the steps implemented during the research data collection and analysis phases. In addition, the researcher exposes the most important data collected in this research to empower new researchers/investigators to use them again. The data collection procedures and data analysis procedures are explained explicitly with in-depth details in Chapter 5. For example, that chapter shows the types of data collected, the means of collection, and the purpose of each type. In short, the researcher has designed his research methodology to ensure reliable outcomes that others can replicate.

4.7 Ethical considerations

The ethical aspect of any research must be taken seriously by researchers to safeguard the participants' wellbeing and protect data confidentiality. The ethics committee at Victoria University asked the researchers to meet high ethical standards that comply with the National Statement on Ethical Conduct in Human Research in Australia. Accordingly, the researcher implemented several steps that satisfy the ethical considerations related to the participant wellbeing and data confidentiality, as will be explained in the following sections.

Participant wellbeing

All participants in this research contributed voluntarily after they received enough information about the research purposes, their roles in the research, the potential risks involved, and their rights to withdraw from research. The researcher reached them in person and handed them the Information to Participants letter before they signed the Consent Form (both documents are in Appendix A). During the data collection, the researcher worked hard to avoid long observations or interviews. He knew the best times for observations and interviews after asking about the case company's peak times. Therefore, he interacted with participants when he saw them comfortable. The right to withdraw from participation was repeatedly mentioned to participants to make sure that they did not feel enforced.

Data Confidentiality

This research discusses sensitive data, which is the cost of the supply chain at a case company. For confidentiality, some data were disguised to protect the case company, case customer, and participants' sensitive data. However, this step did not sacrifice the quality of the model construction. For example, the cost and profit data were manipulated equally to ensure similarity between the exposed results and the genuine numbers. Company names were changed to unreal ones, and locations of restaurants and trip routes were not shown explicitly. In addition, during the data collection phase, the researcher used an iPad to write notes and collect documents digitally. No papers were collected or used to avoid data exposure if those documents were taken to the researcher's office.

Conclusion

This chapter addresses the methodological background and approach underpinning this research. The researcher adopts the pragmatism paradigm, which allows researchers to have a high level of freedom to move between qualitative and quantitative data and means. The researcher needs this freedom to develop a case study design that can help to meet this research aims. Using multiple collection means, the researcher used semi-structured interviews, field observations, and document review to collect qualitative and quantitative data from a case company in Saudi Arabia. These data were collected to ensure a reasonable level of reliability and validity for the research's outcomes. In addition, data were collected under a restricted set of metrics to ensure data confidentiality. The next chapter, Case Study Protocol, shows how the researcher worked with these data regarding collection and analysis procedures. It is a detailed guideline for those interested in the case study design, especially if they aim to develop TD-ABC models.

Chapter 5 : Case Study Protocol

Introduction

Gibbert et al. (2008) suggest that case-study research can show its strength and rigour by enabling investigators and readers with the case-study protocol and database. This chapter discusses the case-study protocol that the researcher followed during the research stages in two main sections. Section 5.1 starts with the data collection procedures, including the means, steps, documents collected, the purpose of each document, and challenges faced during that stage. Next, the researcher discusses the data analysis procedures in Section 5.2. This section explains how the researcher developed the TD-ABC model step-by-step, how he developed the ABC model to compare it with the TD-ABC model, and how he used the TD-ABC model to generate more insightful profitability reports that cannot be generated by the traditional systems.

5.1 Data Collection Procedures

The data collection procedure was designed to collect both financial and operational data through three primary means: semi-structured interviews, direct observations, and document review. Table 5-1 shows the usage of these means in more detail.

Data about:	Interviews	Observation	Docs. review
Speedy's business model	Yes		Yes
Hummy's business model	Yes		Yes
Processes, activities, steps	Yes	Yes	Yes
Durations of steps	Yes	Yes	
Financial accounts and transactions			Yes
Operational transactions (orders, shipments, invoices, etc.)			Yes
Energy capacity			Yes
People capacity			Yes
Space capacity			Yes
Trucks capacity			Yes
Clearing processes			Yes

Table 5-1: Data collected and means used in this research

5.1.1 Semi-structured interviews:

The researcher started the data collection journey on Jan 1st, 2021. In the first few days, he interviewed the general manager, transportation manager, operation manager, and supply chain supervisor (SCS) individually. The interviews were conducted after gaining their consent to participate in semi-structured interviews for 45-60 minutes. The interviews were recorded using a smartphone for the purpose of reviewing the outcomes. The researcher asked each interviewee a few open-ended questions that aimed to clarify the general picture of the company, its operation processes, and its business model. For example, he asked the general manager about the company's services, customers, size, revenue, and more. The transportation and operation managers were asked more about the transportation and warehouse activities and the resources they consume in their day-to-day businesses. The supply chain supervisor, on the other hand, was interviewed to clarify the core supply chain activities such as demand planning, procurement, and processing orders. Although the outcomes of these four interviews were powerful in understanding the company deeply, there was no need to code or analyse the outcomes. The goal of gathering these answers was to form a clear understanding for the researcher before starting his on-site observations, and for the readers to understand the case well.

5.1.2 Observation

The observation method, as mentioned earlier, is the primary tool used by the researcher to collect operational data from Speedy. The researcher spent approximately 3 months observing the activities performed in the central warehouse and head office. The observation sessions were necessary to achieve two goals: to explore the steps needed to perform each activity, and to measure the time needed to implement each step. As the insights on the process flow were already drawn from the initial interviews, the researcher did not face any difficulties to decide where to start. He started from the supply chain management office to observe the planning and procurement activities and the order processing activity. Next, he moved to the operation floor to monitor how the orders were being picked and prepared for deliveries. After that, the researcher followed one of the transportation department drivers on a real trip to Hummy's location to observe all steps involved in the last-mile delivery. Finally, the financial activities such as costing, invoicing, and claiming for insurance compensations that occur after the logistics activities were observed to integrate all supply activities in one comprehensive chain.

When it comes to observations, the researcher was careful not to interrupt participants during their performance of tasks so he could obtain realistic results. He left participants to act normally for a while, and then he asked for clarifications in between tasks. However, if something else interrupted participants significantly, the researcher paused the stopwatch to exclude that wasted time. Regular and quick chats between participants and other workers were not considered significant interruptions, being a part of any typical workplace.

Supply Chain Management Activities

The researcher observed the SCS when planning for demand, placing purchase orders on behalf of Hummy, and processing Hummy's sales orders for a week. In the beginning, the focus was on the first goal (realising the steps) only by being silent and not interrupting the participant. After a while, when the researcher started to understand how the activities and their steps work, he then wrote these steps down on a digital notepad. A discussion with the participant about these tasks followed to confirm or amend the flow drawn based on the observation notes. Next, the researcher moved to observe the duration of each individual step. The digital stopwatch on the researcher's phone was used to record the duration of steps. For example, when a new sales order came to the SCS's email, and it became ready to process, he notified the researcher to start the timer and use the laps function in between steps to count the duration each individual task separately along with the entire activity's duration. Meanwhile, the SCS kept working normally on generating the sales order with no interruption from the researcher, to ensure representative outcomes. With many repetitions of task performance that were observed and recorded during that week using the same methodology, the average time needed to perform each step was calculated to represent the standard duration for that step in the TD-ABC formula.

Warehouse

As mentioned earlier, Speedy had multiple warehousing locations across Saudi Arabia. The main and biggest warehousing facility was in Dammam City, where the researcher collected data. In that facility, there were three different sections for ambient, chilled, and frozen products. Since the processes across these three sections are identical, there was no need to observe the operational activities in each individual section. Therefore, the ambient warehouse was chosen for the research scope. The air temperature in that warehouse was always between 23-25 °C, which is optimal for the researcher to spend more time on the floor for observations. In the ambient warehouse, Speedy stored shelf-stable food as well as paper and plastic products such as cups, lids, and straws for their customers.

After understanding the order processing activity with the SCS, the researcher moved to the next step, which was the direct observation of the order fulfilment process. The researcher introduced himself and his research aim to the storekeeper and pickers who, mostly, handle Hummy's orders, and he gained their consent to be observed for research purposes. Initially, there was no specific order to be followed by the researcher on the floor. He aimed to gain a general idea about the fulfilment activities and resources not only for Hummy's orders but for all customers. This step allowed the researcher to explore the difference in the fulfilment process between this specific customer's orders and other customers. The researcher, sometimes, had to interact with the participants to get something clarified. For example, when the researcher found that the picker used a handheld device when collecting some orders and did not use it for others, he raised this question with the storekeeper, who explained the reason, which was clarified in the case customer section in the previous chapter. Such early interaction is vital before jumping to write down the steps and durations as it allowed the researcher to perceive the context in which the order fulfilment flow was designed.

After several days of general observations, the researcher focused on specific orders to follow their entire flow from the moment where the storekeeper received the sales order from the SCS until it was ready for delivery. Similar to the technique used in the order processing activity, the researcher shadowed the storekeeper and the pickers who moved together in the warehouse to collect items. Using the digital notepad and stopwatch, the researcher recorded his initial notes about the steps taken. Next, he asked the storekeeper to confirm or amend those notes. Then, he focused on the durations. Five complete orders were observed with tens of products picked and prepared for deliveries. The average time spent per step was taken for the TD-ABC formula development.

Transportation

When the sales orders became ready for delivery, there were dedicated trucks from Speedy in each city to load and deliver these orders to Hummy's locations every morning. Dammam City had only one Hummy restaurant and one dedicated truck. The researcher joined the driver on one trip to that restaurant to explore the steps that happened when the truck left the warehouse. He recorded all steps and durations in his notes. In Riyadh City, there were four branches for Hummy with two dedicated trucks. In Jeddah City, there were two branches and one dedicated truck. The researcher talked to the warehouse storekeepers in Riyadh and Jeddah over the phone to ask them about the routes of trucks. The purpose of knowing this information was to consider the destination between the warehouses and branches according to those routes. The steps and durations for the delivery activities in Riyadh and Jeddah were similar to those observed in Dammam.

Finance

In the finance department at Speedy, one senior accountant was responsible for Hummy's accounts. He processed invoices when receiving sales orders, paid Hummy's suppliers when purchasing new stock, collected payments from Hummy monthly, calculated the cost of new inbound shipments, and raised claims to the insurance company for Hummy's damaged items. Using the same methodology used to observe the supply chain supervisor, the researcher spent around one week with the accountant to understand the steps the accountant performed to implement the aforementioned activities as well as to count the time required for these steps.

5.1.3 Documants review

The TD-ABC model requires more data than what has been collected by observations and interviews. Some data were not available on the floor but in the systems or other sources such as government websites. Therefore, the researcher collected documents and data from different sources, either at Speedy or from external public websites, to complete the development of TD-ABC model requirements. However, not all the collected documents were used for analysis purposes. Some were necessary to understand certain activities in more depth. For example, the researcher obtained the files used for costing inventory. The goal of this step was not to analyse how the inventory cost was calculated but to review the steps needed to perform the costing activity. On the other hand, there were many documents collected for analysis purposes according to the TD-ABC methodology, and Table 5-2 shows that in more details.

Doc. Name	Collected from	Purpose
General Ledger	Finance Dept.	To extract the record of the financial transactions including accounts' names, amounts, etc.
Hummy's transactions record	IT Dept.	To calculate the cost of operational transactions.
Compressors consumption	Maintenance Dept.	To allocate the cost of energy to the cost pools.
Warehouses space capacity	Operation Dept.	To allocate the cost of space to the cost pools.
Salaries details	Finance Dept.	To allocate the payroll expenses to the cost pools.
Absence and presence record	HR Dept.	To extract the time capacity of teams.
Clearing procedures	Government websites	To explore the general processes and requirements for clearing shipments

Table 5-2: Data collected sources and purpose

5.1.4 Data collection challenges

The journey of data collection is not always smooth. All researchers face obstacles along the way. During this research journey, the researcher faced some challenges that were either related to the data collection methods or external circumstances. For the former, the researcher found difficulties when he observed people and asked for their clarification of doing something in their steps because of the differences in expectations. The participants often expected that the researcher would need a high level of information; thus, they did not mention some small steps that they felt were obvious. However, these details were not obvious to the researcher. Missing such steps could affect the results significantly. Therefore, the researcher had to emphasise to participants that he needed the detail of details when explaining the process.

Another challenge is that the researcher was not able to observe a hundred per cent of the steps in a few weeks or months. Some steps either rarely happened or were not easy in terms of counting their durations clearly. For example, one of the SCS's weekly activities was to meet with the customer and discuss the weekly demand plans. Such meetings lasted for around 90 minutes as they went through all products one by one to study the stock and sales performance. For the researcher, it was hard to observe and determine the steps and durations precisely. Therefore, the researcher substituted his own observation with the SCS's estimate. The SCS estimated the average time spent for such meetings and divided it by the number of items the customer had in the system at that time to extract the average time needed to plan for each item.

Regarding the external circumstances, the data were collected during the COVID crisis, when heavy restrictions were applied in some countries. In Saudi Arabia, although the number of COVID cases during the data collection period was relatively low, there were serious actions from Speedy to prevent any spread of COVID cases inside the company. For example, the operation floor was isolated from the admin building for a long time. The accessibility between the two buildings was not easy. The researcher had to move in and out as he had a temporary desk in the admin. building to use for his laptop work while he had most of the observations held on the operation floor. Another impact of the COVID crisis was found in the absence of some significant participants. Due to the travel restrictions, such as the quarantine when arriving in Saudi Arabia, some participants were not able to come back to work when the researcher needed them. For example, two of the department managers were absent for the same reason, and the researcher had to wait until they came back to provide the missing data.

5.2 Data Analysis Procedures

The main aim of this research is to explore the role of the TD-ABC model in integrated supply chain management. This aim includes: exploring how the costs of the 4PL services are modelled under the TD-ABC system, comparing the TD-ABC model outcomes with the traditional ABC system's, and discovering how the TD-ABC model can provide high-quality cost and profit reports. Therefore, to meet these ambitious aims, it was required to:

1. Develop a TD-ABC model that can capture the costs of integrated 4PL services and allocate them to the cost objects such as customers and services accurately.
2. Develop an ABC model to calculate the cost of 4PL services using the ABC methodology and compare it with the outcomes of TD-ABC.
3. Develop cost and profit reports according to the TD-ABC system to compare with the existing system's reports.

5.2.1 Developing the TD-ABC Model for the integrated supply chain management

Anderson and Kaplan (2007) explain the process of building the TD-ABC model, which needs a comprehensive set of equations to calculate the costs of each task within the operation process. However, to develop these equations, we first needed two parameters: the CCRper department or resource pool, and the capacity usage. A lot of operational and financial data is needed to obtain accurate information about those two factors from the company's IT system, accounting books, or observation records. This section shows the seven steps the researcher followed to build the TD-ABC model.

Contol A/c:	760000	GENERAL EXPENSES								
Document Date	Transaction Code	Document No.	Reference	Di	Dept	Narration	Debits	Credits	Balance	Dr/Cr
760101	MANAGEMENT SALARIES & ALLOWANCES			206	1	Opening Balance:	0	0	0	
31-Jan-21	KJV	2102020072		206	1	XXXXX	$$	0	$$	Dr
31-Jan-21	KJV	2102020072		206	1	XXXXX	$$	0	$$	Dr
31-Jan-21	KJV	2102020072		206	1	XXXXX	$$	0	$$$	Dr
						Total:	$$$	0		
						Closing Balance:	$$$	0	$$$	

Figure 5-1: GL structure at Speedy

Step1: The General Ledger Data Extraction

The expense transactions are recorded in the general ledger (GL) in any accounting system. The GL at Speedy was organised in a way that allowed users to understand the transaction detail in depth. Besides the fundamental fields such as account name, account code, date, narration, amount, and balance, the users could find other essential data such as the division and department number, document number, and transaction code (Figure 5-1). These additional data helped the user to link or allocate these transactions to specific objects. At Speedy, every financial transaction was allocated to a specific division and specific department, as Figure 5-1 shows.

The division number at Speedy's GL was not referring to the company's internal divisions, but it referred to some specific customers (Table 5-3). Some expenses were allocated to the customers directly. For example, in the travel expenses account, some trip expenses such as hotel and flight expenses, were allocated to specific customers as the trips were necessary to handle or manage issues that were 100% related to those customers. On the other hand, the department number refers to Speedy's branch or location (Table 5-4). Speedy, as mentioned previously, has different warehouses in Dammam, Jeddah, and Riyadh cities. Any transaction must be recorded and allocated to a department number in the GL to filter the financial results based on the location. Such allocation in the GL data entry is vital to guide the user when reading or analysing the GL more effectively.

Division	Allocated to
206	Not allocated to specific customer
2061	Hummy
2062	Customer X
2065	Customer Y
2069	Customer Z

Table 5-3: Divisions numbers and descriptions

Dept.	Location
1	Head office
2	Dammam
3	Jeddah
4	Riyadh

Table 5-4 Locations numbers and descriptions

The GL records extracted from Speedy's accounting books for Q1-2021 contained more than 10,000 financial transactions. Not all these transactions were necessary for the research analysis purposes. Thus, the transactions that affect assets, liability, or equity accounts were excluded from the analysis as they were not affecting the operational expenses and the cost model development. In other words, the balance sheet's accounts were excluded, and the profit and loss accounts were included. This step led to a huge reduction in the number of transactions to around 2600. Next, the researcher investigated those reduced transactions to remove any record that could be irrelevant to the TD-ABC model development. For example, the accounts of cost of goods sold, sales, income from renting activities, and the transactions allocated 100% to specific customers, other than the case customers, were excluded as well. This second filtration round led to a further reduction of around 500 transactions. The remaining 2100 transactions were organised in categories for the analysis purposes and development of the TD-ABC model in the following categories:

1- Salaries and wages
2- Equipment depreciation
3- Locations rent
4- Transportation expenses
5- Maintenance expenses
6- Utilities expenses
7- Insurance
8- General expenses.

Step2: Resource pools (RP)

The distinct advantage of implementing a TD-ABC model in complex settings such as logistics is its capability to capture the actual costs of operation using multiple cost rates. This advantage is attributed to allocating the supplied resources to multiple resource pools. At Speedy, there were multiple departments and sections in different locations. These departments and sections consumed various resources to perform different activities. The researcher investigated these sections, resources, and activities to group them in multiple resource pools. After deeply investigating Speedy's operational processes, the researcher found that these sections could be grouped into 29 resource pools (Table 5-5). Each resource pool was given a unique ID for analysis purposes. That ID referred to the resource pool's location, category, and sub-category. For example, at Speedy's Dammam location, there were different resources such as people, warehouses, and trucks. The researcher gave this location a specific code (DMM), and gave a unique code for each resource category and sub-category (e.g. WH for warehouses and F for the frozen warehouses). This combination of codes composed one resource pool ID, which is, in this case, DMM-WH-F. Similarly, all other 28 pools were created for the same purpose.

Step3: Assignment of supplied resources to resource pools

Now, we have two crucial components needed to calculate the CCRs, the supplied resources and the resource pools. The next step is to distribute these supplied resources to the resource pools to have each pool's total expenses that occurred during Q1-2021. The researcher distributed the supplied resources to the resource pools based on the transactions' narration and cost centre allocation found in the GL records. As mentioned earlier, the GL accounts had rich and informative data that facilitated the assignment of expenses to the different objects. For example, in the GL records, the research found expenses that were allocated directly to the frozen warehouse in Dammam. That expense was for the maintenance of the warehouse freezers. In that case, and similar cases, the researcher allocated expenses from GL to the specific pools directly without needing to use the resource drivers (Table 5-6).

Location	Location code	Category	Category code	sub-category	sub-category ID	Resource Pool ID
Dammam	DMM	Warehouse	WH	Frozen	F	DMM-WH-F
	DMM	Warehouse	WH	Chilled	C	DMM-WH-C
	DMM	Warehouse	WH	Ambient	A	DMM-WH-A
	DMM	Warehouse	WH	External	E	DMM-WH-E
	DMM	Warehouse	WH	SHARE	SH	DMM-WH-SH
	DMM	Warehouse	WH	Support	SP	DMM-WH-SP
	DMM	Labours	LB			DMM-LB
	DMM	Drivers	DR			DMM-DR
	DMM	Trucks	TR			DMM-TR
Riyadh	RYD	Warehouse	WH	Frozen	F	RYD-WH-F
	RYD	Warehouse	WH	Chilled	C	RYD-WH-C
	RYD	Warehouse	WH	Ambient	A	RYD-WH-A
	RYD	Warehouse	WH	External	E	RYD-WH-E
	RYD	Warehouse	WH	SHARE	SH	RYD-WH-SH
	RYD	Warehouse	WH	Support	SP	RYD-WH-SP
	RYD	Labours	LB			RYD-LB
	RYD	Drivers	DR			RYD-DR
	RYD	Trucks	TR			RYD-TR
Jeddah	JED	Warehouse	WH	Frozen	F	JED-WH-F
	JED	Warehouse	WH	Chilled	C	JED-WH-C
	JED	Warehouse	WH	Ambient	A	JED-WH-A
	JED	Warehouse	WH	SHARE	SH	JED-WH-SH
	JED	Warehouse	WH	Support	SP	JED-WH-SP
	JED	Labours	LB			JED-LB
	JED	Drivers	DR			JED-DR
	JED	Trucks	TR			JED-TR
Head office	HED	Management	MG			HED-MG
	HED	Accounts	AC			HED-AC
	HED	Supply chain	SC			HED-SC

Table 5-5: Resource Pools ID Directory

Resource Pool ID	Transportation	Rent	Salaries	Depreciation	Maintenance	Utilities	Insurance	General Expenses
DMM-WH-F								
DMM-WH-C								
DMM-WH-A								
DMM-WH-E		Direct allocation				Direct allocation		
DMM-WH-SH		Direct allocation		Direct allocation	Direct allocation	Direct allocation	Direct allocation	
DMM-WH-SP		Direct allocation						
DMM-LB		Direct allocation	Direct allocation					Direct allocation
DMM-DR			Direct allocation					
DMM-TR	Direct allocation						Direct allocation	
RYD-WH-F								
RYD-WH-C								
RYD-WH-A								
RYD-WH-E		Direct allocation						
RYD-WH-SH		Direct allocation		Direct allocation	Direct allocation	Direct allocation	Direct allocation	
RYD-WH-SP		Direct allocation						
RYD-LB		Direct allocation	Direct allocation					Direct allocation
RYD-DR			Direct allocation					
RYD-TR	Direct allocation						Direct allocation	
JED-WH-F								
JED-WH-C								
JED-WH-A								
JED-WH-SH		Direct allocation		Direct allocation	Direct allocation	Direct allocation	Direct allocation	
JED-WH-SP		Direct allocation						
JED-LB		Direct allocation	Direct allocation					Direct allocation
JED-DR			Direct allocation					
JED-TR	Direct allocation						Direct allocation	
HED-MG		Direct allocation	Direct allocation					Direct allocation
HED-AC			Direct allocation					
HED-SC			Direct allocation					

Table 5-6: Direct Expense Assignment to RPs

The resource pools were either operating or supporting. At Speedy, there were 22 operating resource pools and seven supporting ones. The operating pools were those directly associated with the supply chain and logistics activities, while the supporting pools were indirectly involved in those activities. For example, Speedy had multiple warehouses in each city. Some of these warehouses had no operation and were rented from a third party to store excess inventory. When spaces in the operating warehouses became available, the operation teams transferred stock from the supporting to the operating ones. The customer orders, however, were being fulfilled from the operating warehouses only. That made the researcher differentiate between the two types of pools and assign the supporting to the operating ones based on resource drivers.

Another reason to reallocate expenses from one pool to another is that some pools are huge and cannot be controlled unless they get smaller. At Speedy, there were three main warehouses in the three cities Dammam, Riyadh, and Jeddah. These warehouses were huge in terms of the space and resources they needed. Inside each warehouse of those three, there were three sections: ambient, chilled, and frozen. Although all sections provided the same service, which was the storage service, each section consumed variant resources as they had different temperature settings. This differentiation in resource consumption led the researcher to assume that the cost of storing items should differ from one section to another. Consequently, each main warehouse should be divided into three sections (pools). However, the GL record didn't mention these three sections in most expenses transactions. For example, the rent account had only one monthly transaction, which was the one for the main warehouse. The researcher, therefore, had to reallocate this expense (and other similar expenses) to the three sections (pools) based on the resource driver, as Table 5-7 shows.

Resource Pool ID	Rent	Depreciation	Maintenance	Utilities	Insurance
DMM-WH-F (1)	# of pallets	# of pallets	# of pallets	# of KWs	# of pallets
DMM-WH-C (2)	# of pallets	# of pallets	# of pallets	# of KWs	# of pallets
DMM-WH-A (3)	# of pallets	# of pallets	# of pallets	# of KWs	# of pallets
DMM-WH-E (4)		# of pallets	# of pallets		# of pallets
DMM-WH-SH (5)	To (1, 2,3)	To (1,2,3,4)	To (1,2,3,4)	To (1, 2,3)	To (1,2,3,4)
DMM-WH-SP (6)	To (1, 2,3)				
DMM-LB					
DMM-DR					
DMM-TR					
RYD-WH-F (10)	# of pallets	# of pallets	# of pallets	# of KWs	# of pallets
RYD-WH-C (11)	# of pallets	# of pallets	# of pallets	# of KWs	# of pallets
RYD-WH-A (12)	# of pallets	# of pallets	# of pallets	# of KWs	# of pallets
RYD-WH-E (13)		# of pallets	# of pallets		# of pallets

RYD-WH-SH (14)	To (10, 11,12)	To (10,11,12,13)	To (10,11,12,13)	To (10, 11,12)	To (10,11,12,13)
RYD-WH-SP (15)	To (10, 11,12)				
RYD-LB					
RYD-DR					
RYD-TR					
JED-WH-F (19)	# of pallets	# of pallets	# of pallets	# of KWs	# of pallets
JED-WH-C (20)	# of pallets	# of pallets	# of pallets	# of KWs	# of pallets
JED-WH-A (21)	# of pallets	# of pallets	# of pallets	# of KWs	# of pallets
JED-WH-SH (22)	To (19, 20,21)	To (19, 20,21)	To (19, 20,21)	To (19, 20,21)	To (19, 20,21)
JED-WH-SP (23)	To (19, 20,21)				
JED-LB					
JED-DR					
JED-TR					
HED-MG					
HED-AC					
HED-SC					

Table 5-7: Indirect Expenses Assignment to RPs

Step4: The Practical Capacity

The denominator of the CCR equation is the practical capacity. The practical capacity is the capacity available to operate the business after excluding break times, holidays, training time, etc, from the theoretical capacity. According to Kaplan and Anderson (2004), this number can be obtained in two different ways. First, the arbitrary approach that assumes a certain percentage of the theoretical capacity (e.g. 80 or 85% of the total time). Or secondly, by using the analytic approach that implies that the resources are available for a certain number of minutes during the month after deducting breaks, training, maintenance, meetings, and all other times that those resources are not available within. The researcher followed the second approach to calculate the practical capacity of people as it is more accurate and reliable than the arbitrary one. Table 5-8 shows the number of labourers, drivers, and employees in each location per each month.

At Speedy, employees and workers worked under two different systems. Admin. people like the finance team worked five days a week and enjoyed more vacation days. On the other hand, labourers, drivers, and supply chain teams worked six days a week and enjoyed fewer vacation days than the management people. Thus, the latter group provided more practical capacity than the former one. Tables 5-9 and 5-10 show the breakdown of the practical capacity calculation per each group that has been used for the TD-ABC model development in this research.

Role	DMM-LB			JED-LB			RYD-LB		
	JAN	FEB	MAR	JAN	FEB	MAR	JAN	FEB	MAR
Labours	39.00	39.00	40.00	14.00	13.00	12.00	11.00	15.00	21.00

Role	DMM-DR			JED-DR			RYD-DR		
	JAN	FEB	MAR	JAN	FEB	MAR	JAN	FEB	MAR
Drivers	32.00	32.00	32.00	17.00	17.00	17.00	27.00	27.00	27.00

Role	RP ID	# of Head
Supply chain supervisor	MG-SC	1
Finance Manager	MG-AC	2
Senior accountant		

Table 5-8: Number of FTEs Available in RP in Q1-2021

TD-ABC - Estimating Practical Capacity (per each worker FTE)

Days a year	365	
Weekends (1 day*52 weeks)	52	
National/Local Holidays	9	
Vacation days	21	
Expected days for personal and sick leave		
This leaves with	283	days per year
or	23.6	days per month
Suppose further that employees show up for	9	hours per day
or	540	minutes per day
Time for lunch	30	minutes per day
Average time for breaks	30	minutes per day
Average time for meetings	0	minutes per week
Average time for training and education	8	hours a year
Total minutes available per worker to perform actual work	472.0	min/day

Total minutes available for performing actual work	133576.0	min/year
Total minutes available for performing actual work	11131	min month

Table 5-9: The Practical Capacity Breakdown Per Each Worker in Speedy in Q1-202

TD-ABC - Estimating Practical Capacity (per each Admin FTE)

Days a year	365	
Weekends (2 days*52 weeks)	104	
National/local holidays	9	
Vacation days	30	
Expected days for personal and sick leave		
This leaves with	222	days per year
or	18.5	days per month
Suppose further that employees show up for	9.5	hours per day
or	570	minutes per day
Time for lunch	30	minutes per day
Average time for breaks	0	minutes per day
Average time for meetings	30	minutes per week
Average time for training and education	32	hours a year
Total minutes available per employee to perform actual work	524.86	Min/day

Total minutes available for performing actual work	116518.9	Min/year
Total minutes available for performing actual work	9710	Min/ month

Table 5-10: The Practical Capacity Breakdown per each Admin FTE in Speedy in Q1-2021

Calculating the practical capacity is not limited to human capacity but can be applied to other resources. At Speedy, there were two important resources other than people – trucks and spaces. Speedy used these resources to provide delivery and storage services. However, these resources cannot be utilised endlessly. Some limitations prevented Speedy from utilising those resources at the 100% level. For example, trucks cannot be used without drivers, which had their own practical capacity limitations. Thus, the practical capacity of trucks was dependent of the practical capacity of the drivers. In addition, the speed limits on streets and roads form another limitation for the trucks' total capacity. Truck drivers cannot increase the capacity of trucks by speeding up. The researcher has considered those two factors (driver availability and speed limits) to calculate the practical capacity of trucks when developing the TD-ABC model.

Similarly, the warehouse space had some limitations that affected the storage capacity. Speedy uses American-standard pallets in its warehouses. This type of pallet has specific dimensions that can be measured in cubic metres (CBM). The company cannot exceed the allowable volume in each pallet as it may damage the products. Tables 5-11, 5-12 and 5-13 show the total capacity of spaces, trucks, and energy (respectively) in each related resource pool.

RP ID	# Pallets
DMM-WH-F	6074
DMM-WH-C	2652
DMM-WH-A	2292
DMM-WH-E	4998
JED-WH-F	564
JED-WH-C	1340
JED-WH-A	2116
RYD-WH-F	1488
RYD-WH-C	515
RYD-WH-A	408
RYD-WH-E	1884

Table 5-11: Warehouses Total Capacity in Q1-2021

RP ID	# of Trucks
DMM-TR	30
JED-TR	17
RYD-TR	27

Table 5-12: Trucks Total Capacity in Q1-2021

RP ID	KW capacity
DMM-WH-F	917.5
DMM-WH-C	354
DMM-WH-A	468
RYD-WH-F	117
RYD-WH-C	33.6
RYD-WH-A	22.4
JED-WH-F	160.4
JED-WH-C	52
JED-WH-A	135

Table 5-13: Energy Total Capacity in Q1-202

At this stage, the researcher has two important variables to calculate the CCR: the supplied expenses and the practical capacity per each resource pool. These two variables allow us to know how much the cost is per resource unit. For example, if we consider the supply chain management pool, we know the expenses supplied to that pool in Q1-2021. We also know the practical capacity for that pool (minutes available for work). As CCR Equation 5.1 suggests, we can divide the total supplied expenses by the practical capacity to get the cost per minute. The researcher applied this equation with all 22 supporting resource pools to get 22 cost rates. However, not all rates represent the cost per minute. Some pools have different cost drivers other than time. While warehousing pools have the CBM as a cost driver, the researcher used the destination measure kilometre as a cost driver for the transportation pools (for truck expenses). Table 5-14 shows each resource pool and its relevant cost driver.

Category	RP ID	Cost driver	Category	RP ID	Cost driver
Warehouses	DMM-WH-F	CBM	People	DMM-LB	Min
	DMM-WH-C	CBM		DMM-DR	Min
	DMM-WH-A	CBM		RYD-LB	Min
	DMM-WH-E	CBM		RYD-DR	Min
	JED-WH-F	CBM		JED-LB	Min
	JED-WH-C	CBM		JED-DR	Min
	JED-WH-A	CBM		HED-AC	Min
	RYD-WH-F	CBM		HED-SC	Min

	RYD-WH-C	CBM		DMM-TR	km
	RYD-WH-A	CBM	Trucks	RYD-TR	km
	RYD-WH-E	CBM		JED-TR	km

Table 5-14:The Cost drivers per each RP

$$CCR = \frac{\text{Supplied expenses}}{\text{Practical Capacity}}$$

Equation 5-1: The CCR equation

Step5: Defining activities

The previous steps show the analysis process needed to calculate the CCR per each resource pool. Although that process consists of multiple subsequent steps, the researcher suggests that all these steps should be considered as one building block in the TD-ABC model development. Obtaining the CCR per pool without analysing the operation processes is meaningless. The TD-ABC model needs a deep understanding of the case company's integrated logistics activities. Therefore, the researcher observed Speedy's integrated supply chain and logistics activities to supply Hummy's branches with the required food and materials**.** These activities included Demand Planning, Procurement Branch Transfers, Processing Orders, Picking & Loading, Receiving Shipments, Delivery, Costing, Invoicing, and Claims Management. Each activity was divided into multiple steps, and the time of each step was determined according to the research's observations. Tables of activities, then, were developed to show each activity's steps and duration. Those tables were helpful in the process of time equations development.

Step6: Developing the TD-ABC equations

The researcher now has the CCR per each pool for every month in Q1-2021 and has the time needed to implement each step in the integrated supply chain processes at Speedy. These two data sets were necessary to develop the time equations, which are the heart of the TD-ABC model. To further develop the TD-ABC model, the researcher needed to use more advanced software to construct the TD-ABC equations and allocate the overhead cost. The researcher used Microsoft Excel to construct the TD-ABC formulas that calculated the operations costs.

Step7: Allocation of overhead costs to the cost objects

The time equations are now constructed. In the normal TD-ABC models, the cost allocation from activities to the cost objects is determined by how much each cost object consumed from activities according to the equations. These cost objects could be customers, channels, products, DCs, suppliers, or more. In this research, the researcher focused on one cost object, which is the customer. The researcher aimed to understand how much each customer consumed from Speedy's resources. However, since there is only one case customer in this research, the researcher dealt with each branch as a separate customer as they place different orders with different quantitates to be delivered to different locations.

For some activities, the relation between branches and activities was not direct. Product Registration, Demand Planning, Procurement, and more were examples of activities that were performed on the level of the group company rather than the individual branches. The researcher, therefore, allocated the cost of such activities in two steps. First, he allocated the overhead cost from activities to the group customer. Second, he allocated the cost from the group customer to branches based on one cost driver, which was the number of sale orders. This cost driver was chosen as the most relevant one to this scenario. Activities such as Demand Planning and Procurement were not driven by anything but the future sales orders from branches.

For the activities that had a direct correlation with branches such as Processing Orders, Delivery, and Picking & Loading, the allocation was implemented directly in one step based on relevant cost drivers. Table 5-15 demonstrates the allocation details per each activity.

Activity	Cost object – 1	Cost object – 2	Cost driver
Product registration	Group customer	Branch	Sales orders
Demand Planning	Group customer	Branch	Sales orders
Procurement	Group customer	Branch	Sales orders
Branch Transfer	Group customer	Branch	Sales orders
Warehousing	Group customer	Branch	CBM
Processing Orders	Branch		Nr. Of items
Picking and loading	Branch		Nr. Of cases
Receiving shipments	Group customer	Branch	Sales orders
Delivery	Branch		Nr. Of cases
Costing	Group customer	Branch	Sales orders
Invoicing	Branch		Sales orders
Insurance claims	Group customer	Branch	Sales orders

Table 5-15: Cost Drivers Used for Cost Object Overhead Cost Allocations

5.2.2 The comparison between TD-ABC and ABC models

Developing an ABC model

The core distinction between the TD-ABC and ABC models can be found, first in the assignment for the overhead cost from resource pools to activities, and second from activities to the cost objects. On the other hand, both systems share the exact allocation mechanism when we pass the overhead cost from the GL down to the resource pools, as Figure 5-2 suggests. This similarity and difference between the two methodologies led the researcher to duplicate some elements of the TD-ABC model developed in the previous part and to build some new elements from scratch. To illustrate, the researcher used the same GL allocation method when he developed both TD-ABC and ABC models, as the same expenses were allocated to the same resource pools. On the other hand, the mechanism of assignments from resource pools to activities down to cost objects in both systems, TD-ABC and ABC, were different. In TD-ABC, the overhead assignment from resource pools to activities and the cost objects was based on the equations that calculated the resource consumption. On the other hand, in the ABC model, the overhead assignment from resource pools to activities relies on the employee and labour judgements. Employees participate in the allocation process by advising on the percentage of workload that each activity consume compared with the other activities. Next, the overhead was allocated from activities to the cost objects based on the number of transactions in each activity. That means the TD-ABC and ABC models share the same way of overhead allocation from the GL to the resource pools, and they differ in the way of the second-stage allocation, which is from the resource pools to activities and from activities to the cost objects.

For comparison purposes, the researcher picked one resource pool, which was HED-SC, which performed the supply chain activities. This department performed five activities as follows: Demand Planning, Procurement, Processing Orders, Product Registration, and Branch Transfer. The researcher excluded one activity which is Product Registration and used the remaining four activities for comparison between the TD-ABC and ABC system. The reason behind this exclusion is that Product Registration had trivial transactions during Q1-2021. The other resource pools were excluded also from this comparison for two reasons: first, to control the scope of this project within the given timeframe; second, to focus more on the unique activities that haven't been discussed in similar research.

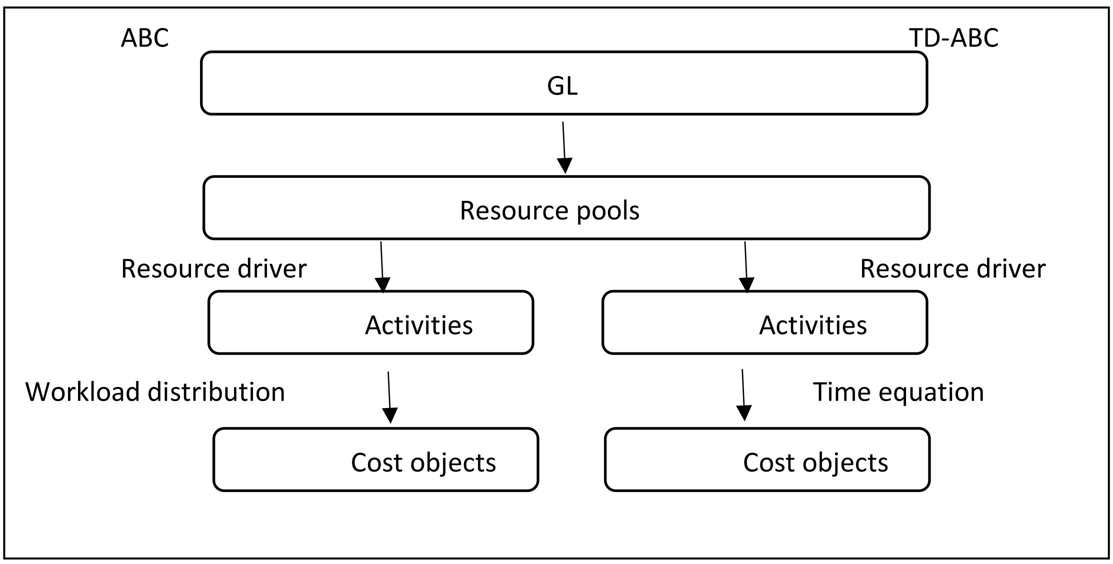

Figure 5-2: The TD-ABC and ABC Assignment Ways

Allocation from activities to cost objects

In the final-stage assignment (from activities to cost objects), the researcher followed the traditional method used in the ABC model. That method is called transaction-based allocation. According to this method, the researcher collected more data related to Hummy and all other customers' transactions from Speedy's system. The number of sales orders, the number of shipments received, and the number of POs generated are examples of the cost drivers in the ABC model. These transactions were the cost drivers responsible for consuming overhead costs from activities. According to the ABC methodology, the overhead allocation from activities to the cost drivers is based on the number of transactions per each activity. For example, the number of pallets can be the cost driver for the storage activity. Thus, we can calculate the cost per pallet by dividing the total overhead costs for Storage activity by the number of pallets available at Speedy (see Table 5-16 for more details about the cost drivers used in this research). The researcher had to divide the total overhead costs assigned to each activity by the total number of transactions in that activity regardless of whether those transactions were assigned to Hummy or not. The goal was to get the overhead allocated to every single transaction before isolating Hummy's transactions for comparison purposes.

Resource Pool ID	Activity	Cost object	Cost driver
HED-SC	Procurement	PO	Nr. Of POs
HED-SC	Demand Planning	Plan	Nr. Of plans
HED-SC	Order Processing	Order	Nr. Of sales orders
HED-SC	Branch Transfers	Transfer request	Nr. Of requests

Table 5-16: ABC Cost Objects and Drivers

5.2.3 The qualty of cost and profitability reports under the TD-ABC model

Finally, the researcher extracted the current system's outcomes that Speedy used for internal decision-making. These outcomes were simple and straightforward. The company used two different reports to measure customer profitability. First, the customer's P&L statement is used for direct cost, where managers can evaluate a customer's performance by comparing revenue generated and the direct cost, such as direct allocation of transportation costs. Secondly, managers use the SC methodology to allocate the overhead costs, such as rent, salaries, electricity, and more. To build a SC system, the company needed to assign one or a few cost drivers per each department. However, Speedy's management used only one cost driver for all departments and overhead costs including people, depreciation, rent, etc. It used the number of pallets as a cost driver. That means the company allocated overhead costs to customers based on the number of pallets that customers utilised. In this research, these two models were compared with the TD-ABC outcomes to shed light on the difference in quality of cost and profit reports between the three sources.

Chapter 6 : Results

Introduction

Supply chain management is crucial for today's modern businesses, where world trade has become prominent. Traders, manufacturers, and even farmers, nowadays deal with their counterparties across continents more rapidly and frequently than ever. This challenge gets greater for the supply chain companies that take the responsibility of meeting this upward momentum by providing sophisticated services to their customers. The case company in this research, Speedy, is one of the best examples of companies that deal with suppliers and customers worldwide. It operates sophisticatedly to provide high-standard services to its customers, such as Hummy. Speedy can be considered a one-stop-shop that provides integrated supply chain services on behalf of its customers, starting from Demand Planning and Procurement to last-mile delivery. This sophistication in operation, unfortunately, is a considerable risk factor for many reasons, especially when the operating costs are not well calculated. Such companies can turn to the loss zone if they fail to capture the actual costs of operation. Although this topic has been discussed in the literature in diverse ways, there is still a gap regarding the role of the TD-ABC model in integrated supply chain management.

In this chapter, the researcher presents the findings of his case-study research on Speedy as a case 4PL company. Section 6.1 aims to highlight the role of the TD-ABC model in capturing the cost of operation when providing a wide range of services beyond the traditional warehousing and distribution ones. And to achieve that aim, the researcher presents the results of his observations of the daily activities at Speedy and his analysis of the documents collected from the operational and financial departments. Both data sources (observations and documents) have helped the researcher develop a simulating TD-ABC model that answers the first research question: "How will the costs of the integrated logistics services be modelled under the TD-ABC approach?"

Section 6.2 compares the cost of integrated supply chain activities under the TD-ABC and the traditional ABC models. This comparison allows the reader to find an answer to the second question of this research: "How will the cost information, under the TD-ABC method, be different from the cost information generated by the ABC system in the case company?" Therefore, this section will be structured in a way that presents the development process of the ABC model in the first part, while the second part will show the comparison results between the TD-ABC and ABC systems in modelling the cost of integrated supply chain services.

Section 6.3 compares the cost and profitability reports generated by the TD-ABC model with the existing reports generated by the case company's system. The company's management relies on the P&L statement as well as the traditional SC system, which relies on one or a few cost drivers for overhead allocation. The cost and profit reports under both TD-ABC, P&L, and SC systems should lead to different conclusions. Thus, this part aims to shed light on those conclusions and provide an answer to the third research question: "How can the TD-ABC model help in improving the quality of the cost and profitability reports?"

6.1 Developing the TD-ABC Model

Step one: GL data Extraction

At Speedy, divergent functions are operating to provide customers with integrated supply chain services. Each function consumes specific amounts of resources to operate under a specific practical capacity. Therefore, the researcher had to explore those consumed resources and capacity in order to calculate the capacity rate, which is the first towards the TD-ABC model development. At Speedy, there are 3 main groups of resources that determine the capacity rates for all functions. These groups are workers, spaces, and trucks. As discussed in the case-study protocol, the first step towards developing the TD-ABC model is to extract the supplied resource expenses from Speedy's GL. The final list of 2100 journal entries that the researcher found in the GL records was analysed and grouped into 146 sub-accounts. These 146 sub-accounts represent the 8 main categories that the researcher created for the TD-ABC model (salaries, depreciation, trucks, rent, maintenance, utilities, insurance, and general expenses). Table 6-1 summarises these expenses by groups for every month in Q1-2021, which totalled SAR 8,094,165.

Category	Sum of January (SAR)	Sum of February (SAR)	Sum of March (SAR)	Sum of Grand Total (SAR)
Employees	767,955.29	768,065.74	770,609.08	2,306,630.11
Equipment and Depreciation	60,891.38	34,680.80	32,420.88	127,993.06
General Expenses	255,262.21	226,828.70	247,277.25	729,368.16
Insurance	11,783.00	11,783.00	11,783.00	35,349.00
Maintenance	77,374.64	41,737.94	44,984.31	164,096.89
Transportation	485,909.32	479,482.91	452,390.89	1,417,783.12
Utilities	243,102.26	270,945.38	274,300.37	788,348.01
warehouses	802,939.00	805,428.00	916,230.50	2,524,597.50
Grand Total	2,705,217.10	2,638,952.47	2,749,996.28	8,094,165.85

Table 6-1: Expenses categories and amounts in Q1-2021

Step two: Resource Pools

The resource pools now are ready to receive the allocated overhead expenses. The researcher, as mentioned in the case-study protocol, allocated the overhead expenses to the resource pools in two subsequent stages. First, the overhead expenses were allocated to resource pools directly depending on the GL's detail. Next, overhead expenses from supporting resource pools were allocated to the operating resource pools depending on the resource drivers. For example, the rent expense for warehouses was recorded in one transaction per city. Three operating resource pools were created inside every single warehouse to differentiate between the frozen, chilled, and ambient sections. Every section consumes varying amounts of resources, especially those related to maintenance and energy. The overhead (rent) from one sharing/supporting pool was allocated to multiple operating pools. Table 1 in Appendix B shows the final allocated overhead for each operating resource pool in January, February, and March 2021.

Step three: The Practical Capacity

The resource capacity data is the second important variable needed to calculate the CCR. At Speedy, the integrated supply chain process relies on three different types of resources: people, spaces, and trucks. Each type has its own measure. While the labour capacity is measured by time, the space capacity is measured by cubic metres, and the truck capacity is measured by destination in kilometres. It can be seen clearly that Speedy devotes most of its capacity to Dammam City's facilities. That's because it's the central location where most shipments arrive from customers and suppliers before they get distributed to the other cities. Table 6-2 shows the practical capacity per each type of resource. Tables 2 to 7 in Appendix B show the resources' theoretical and practical capacity per each resource pool in January, February, and March 2021.

Resource driver	Practical capacity	Unit of measurement
Pallet	1.24	CBM
FTEs - Labour	11131	Min/month
FTEs – Admin.	9710	Min/month
Trucks	9440	km/month

Table 6-2: The practical capacity per each resource type

Step four: CCRs Calculations

By dividing the allocated overhead costs (step one) by the practical capacity (step three) for each resource pool, we can, finally, obtain the CCR for that pool. To illustrate, if we applied this equation to the resource pool DMM-LB in January 2021, we would get the following result:

CCR (DMM-LB) = supplied resource expenses (SAR) /practical capacity (min)

= SAR 373,774.40/434122 min

= SAR 0.86/minute

That means every minute spent on performing logistics activities by that pool costs Speedy 0.86 Saudi Riyals. And, if activity A needs one FTE and 10 minutes to complete that activity, the total cost of performing activity A once is 8.6 Saudi Riyals. The following sections show that in more detail. Tables 8, 9, and 10 in Appendix B show the CCR per each resource pool in January, February, and March 2021, respectively.

Step five: Defining Activities

The following eight sections show the results of the researcher's observations of the integrated supply chain activities at Speedy. Each section consists of three main parts: first, the full explanation of the process and steps needed to implement every single activity; second, the researcher summarises activities in flowcharts to visualise the sequence of steps; third, the time and number of FTEs needed to implement each step. However, before proceeding to the following sections, it is essential to shed light on the flowchart symbols to help readers understand the process steps adequately. Figure 6-1 shows each symbol and its meaning in the flowcharts in this research. The researcher used some of the symbols developed by the American Society of Mechanical Engineers (ASME).

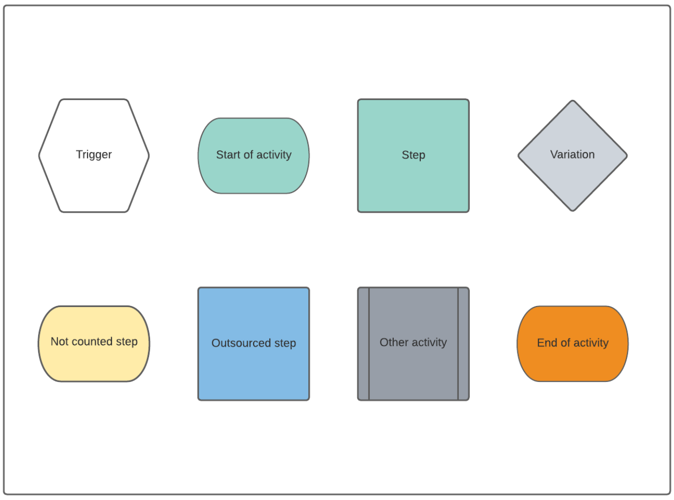

Figure 6-1: The flowchart symbols

Products Registration

The products Speedy purchased from suppliers on behalf of Hummy could be categorised into food and non-food products. When purchasing food products from international suppliers, Speedy must comply with the Saudi Food and Drug Authorization (SFDA) requirements. All imported products must be registered and approved by SFDA before they arrive at Saudi Customs. Therefore, Speedy registered all food products in advance when it signed the contract with Hummy. When adding a new product to Hummy's items list, Speedy must register it before purchasing. Or, if an existing product's ingredients, name, or nutrition facts changed, Speedy had to re-register it with the new changes. Internally, the process of registration, as Figure 6-2 shows, started with the collection of the product's information from the customer Hummy. Hummy provided the product's name, brand, content, the Harmonized System (HS) code, barcode, trademark, image of the card product, and other information related to the manufacturer/producer.

In some cases, the customer failed to provide the image of a card product (artwork), and the supervisor then had to design this card from scratch, which consumed, on average, 30 minutes of his time. Once he collected all this information and files ready for the SFDA application, he sent it out to the supply chain coordinator at the holding company that owns Speedy. The coordinator there was responsible for all product registration across all operating child companies, including Speedy. SFDA has an online portal that companies use to upload documents. According to the coordinator, the application for a new product registration did not take more than five minutes to fill in all fields required at the SFDA portal. After a comprehensive review of the submitted application and maybe several communications back and forth, SFDA sends the certificate of registration to Speedy as a green light to import the registered items.

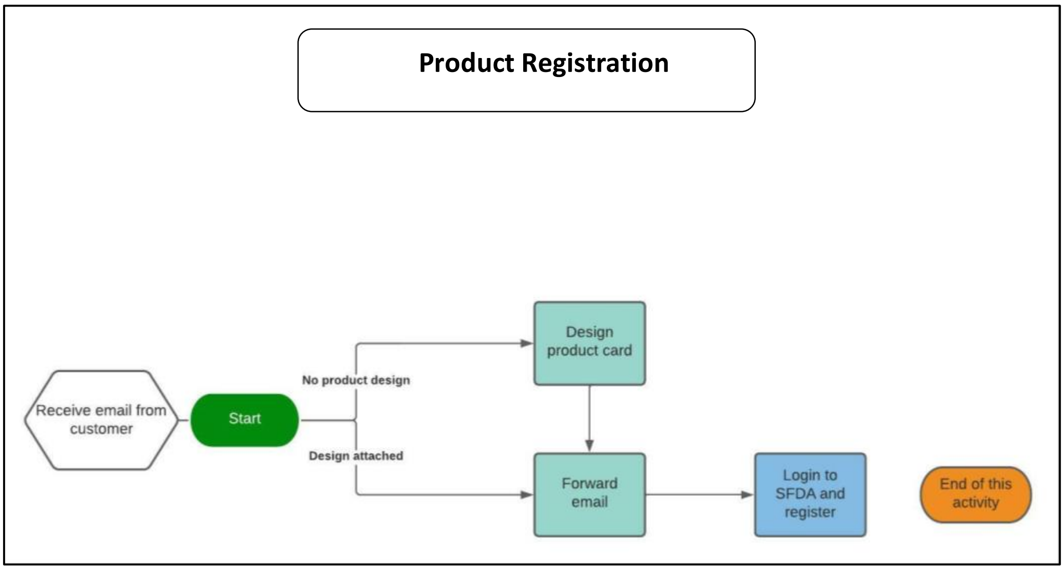

Figure 6-2:The Product Registration activity flowchart

For non-food products such as packaging items, Speedy must comply with SABER requirements to import products from overseas. SABER is another platform that issues Certificates of Conformity to investors and manufacturers who want to trade non-food goods in the Saudi market. The platform requires product registration for items that fall under specific categories and have particular HS Codes. In contrast to what happens when registering new food items at the SFDA portal, Speedy outsourced the registration of non-food items to a third party handling the entire process. According to Speedy's SCS, SABER requirements are complicated and not straightforward. Thus, Speedy preferred to outsource this part of the process to an external party who was more professional and expert in quality assurance and compliance requirements. See Table 11 in Appendix B which shows Product Registration activity steps and durations.

Demand Planning

The integrated supply chain services that Speedy provided to its customers started with Demand Planning, as it was the first step in the entire process. As Speedy managed the procurement and flow of the raw materials and packaging products on behalf of Hummy, Speedy assigned a dedicated SCS to plan and manage this task for all of Hummy's outlets. The supervisor was responsible for monitoring and analysing the inventory and sales reports every week to ensure decent stock levels of each SKU in each branch for the next four months. According to the supervisor, he implemented this activity once or twice every week by following these steps:

1- Downloading the quantity on hand (inventory) report.
2- Downloading the previous consumption reports to analyse the consumption rates in the last four weeks, last three months, and the same month in the last year.
3- Forecasting the average consumption rate based on the previous steps.
4- Generating the aging days' report for each SKU based on the forecasted consumption rate.

Based on the forecast aging days report, the supervisor can conclude what SKUs need replenishments from vendors and when he should initiate that. However, as he had no full authority to create purchase orders (POs) based on his own decision only, he needed to discuss his analysis outcomes with the customer's supply chain team. The two parties scheduled long discussion meetings that, on average, last for 90 minutes. During those meetings, participants reviewed and contributed to the analysis outcomes by going through the SKUs one by one. In some cases, Hummy's team had a different point of view about the forecast outcomes based on the exclusive information that they had access to. For example, future events such as new openings, public holidays, religious occasions, school calendar, etc could affect the forecasted outcomes significantly. The outcomes of those meetings were formulated as draft POs. The OBA approach facilitated a transparent dialogue between Speedy and Hummy, ensuring that both parties had a clear understanding of the cost implications of the demand planning decisions. Figure 6-3 summaries the entire flow of the demand plan activity.

When Speedy's SCS received approval from Hummy's team on the draft POs, he implemented container capacity planning. Speedy deals with 14 international suppliers who produce and ship Hummy's products by sea in containers. While most orders contain products from one supplier in huge quantities that can fill the entire container, in some other cases, the orders contain products from multiple suppliers with smaller quantities from each. That implies that it's inefficient to ship multiple containers from multiple suppliers if they're departing from the same country of origin. Therefore, Speedy dealt with forwarding companies that receive products from multiple suppliers and consolidate them in one or two containers. In both scenarios, Speedy must optimise the container capacity, whether shipped from the suppliers directly or from consolidators, in order to maximise the benefit from the container space, thus reducing the shipping cost. The SCS used a container capacity calculator to calculate the total CBM of the products ordered and compared it with the standard container CBM. Since the products were categorised into chilled, frozen, and dry groups, the supervisor needed to consider these groups while planning the container where each product should be shipped in the proper container. According to the SCS, the POs quantities could be adjusted (increased or decreased) from the original plan based on the results of the container capacity analysis. However, this had to be approved again by Hummy's supply chain team. The OBA framework, in this scenario, played a crucial role in ensuring that the cost adjustments and the subsequent impact on pricing were transparently communicated and agreed upon between Speedy and Hummy. See Table 12 in Appendix B for the Demand Planning activity steps and durations.

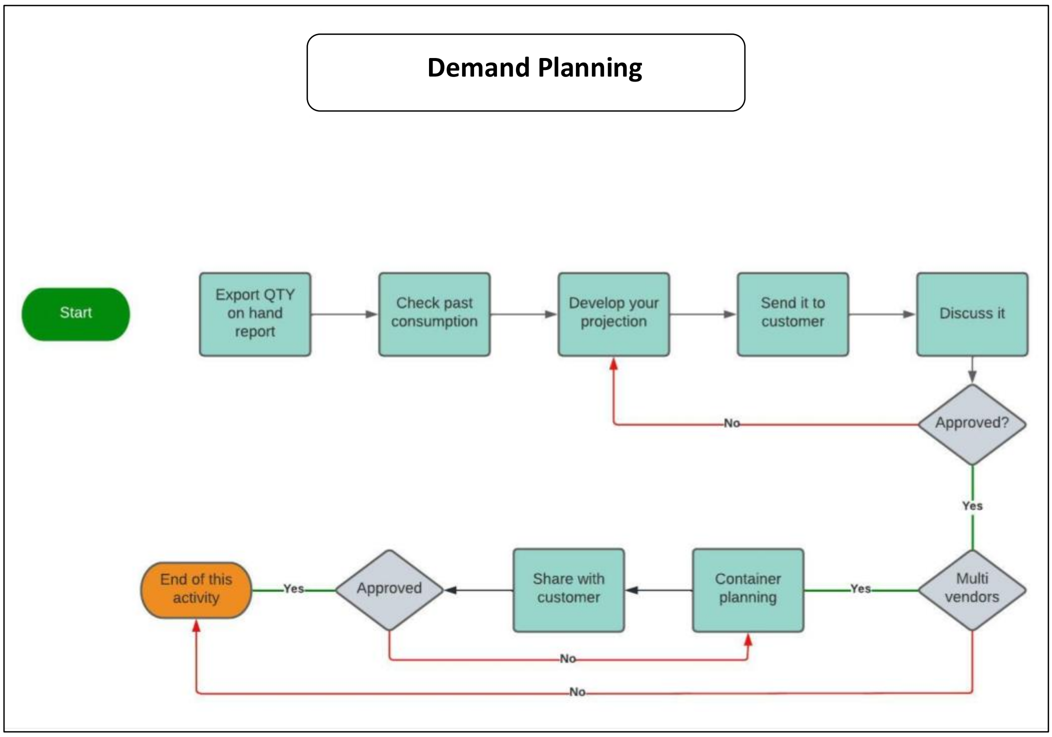

Figure 6-3: The Demand Planning activity flowchart

Procurement

Upon Hummy's approval of the draft PO and the container capacity plan developed by Speedy's supervisor, the procurement activity started with an official quote request sent by the supply chain supervisor at Speedy. As mentioned in the previous activity, some orders could be fulfilled by one supplier, and some needed a forwarding company to consolidate multiple orders in one or more containers. In the case of one supplier, the supervisor sent the quotation request to the supplier directly. If the order contained multiple items from different sources, the request was sent to the consolidator, who created and sent sub-orders to the suppliers on behalf of Speedy. For some products, multiple suppliers can produce the same product, and they're all approved by Hummy. In that case, Speedy's supervisor sent the same quote request to all alternatives to receive different rates and lead times. The supervisor then studied the quotations received from the suppliers/consolidators and decided which supplier/consolidator could provide the best quote regarding the lead time first and the rates second. The lead time, according to the supervisor, had a higher priority than the rates when comparing quotes.

When the SCS received the best quote from suppliers, he generated an official PO using Speedy's ERP system. That PO went to Speedy's general manager for approval and signature, and once it was signed and approved, a copy went to the supplier/consolidator to initiate the order process. The supplier/consolidator sent a confirmation email to Speedy's supervisor to confirm the quantity, rates, shipping terms and time, and destination. Later, when the order was prepared for shipping, the supplier/consolidator emailed Speedy's supervisor with a digital copy of the order shipment documents. These documents included the commercial invoice, packing list, health certificate, certificate of origin, loading bill, and shipment insurance. The supervisor validated these documents and sent his confirmation to the finance department to pay the order invoice. Although Speedy used to pay orders in two different ways online and offline, all recent payments, including the ones that were observed by the researcher, were paid online only. Online payments are faster and cost less than offline payments, which require a lot of communication between the supplier's bank and Speedy's bank.

When Speedy paid a supplier, the original shipment documents were mailed by an international courier to Speedy's address. Against those documents, Speedy started the process of clearance. However, before that, the shipment must be registered in the SFDA portal if it had food items or the SABER portal if it had non-food items. It's important to differentiate here between product registration, which has been discussed in the previous section, and shipment registration. While the former associates with the product compliance with the local regulations and standards, the latter is required as a notification every time registered products arrive at Saudi Customs. The shipment registration process, contrary to product registration, was easy and short. The SFDA requires basic information, including the order detail (items and quantity) and the clearance broker detail. SABER require a copy of the shipment documents. Like the product registration, Speedy handled the shipment registration at the SFDA portal internally and outsourced the SABER shipment registration through the external partner.

After registering shipments on SFDA or SABER portals, the SCS delivered the shipment documents to the clearance broker. Speedy outsourced the shipment clearance processes to a few external parties who were familiar with Speedy's products. Although there are six commercial seaports in Saudi Arabia, most of Speedy's shipments arrived at the King Abdelaziz Sea Port in Dammam City, where Speedy's head office and the central warehouse are located. When the broker received the shipment documents, he started the process to generate what so-called Bayan. Bayan is a manifest issued by the Saudi Customs that shows the shipment detail, including the customs duty and tax. When Bayan was issued, the broker shared it with Speedy to process the customs duty payment. After payment, the shipment became ready for delivery. The broker transported the container, usually using his own truck, to Speedy's central warehouse.

For orders placed with local suppliers, the process was much easier and shorter, where there was no need to register products or shipments. In addition, as they're from local suppliers, there was no clearance process involved. Figure 6-4 summarises the entire Procurement activity flowchart, and Table 13 in Appendix B shows the steps and durations of the Procurement activity.

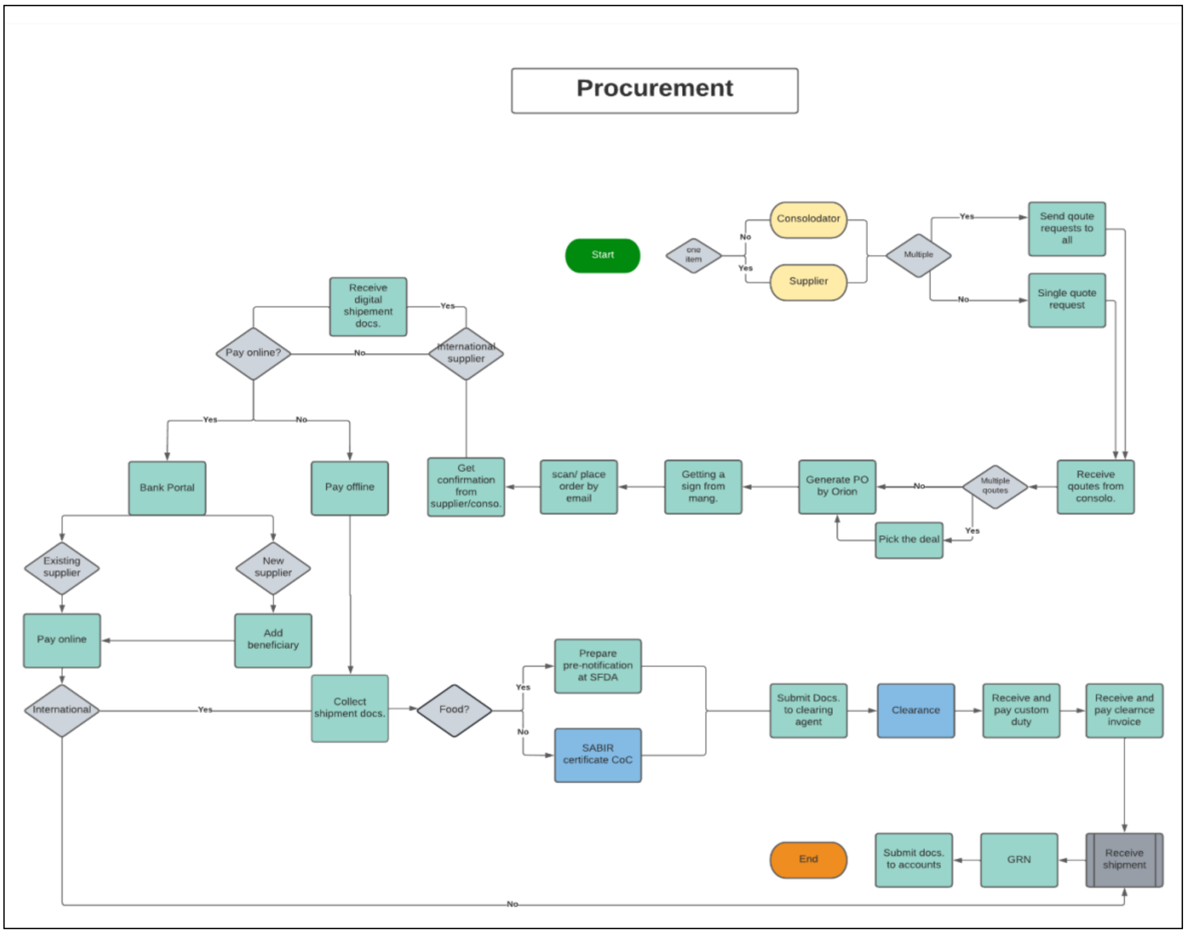

Figure 6-4: The Procurement activity flowchart

Receiving shipments

Speedy received tens of shipments every week from both international and local vendors. The process of receiving shipments, as Figure 6-5 shows, started with the dock assignment. The storekeeper assigned a dock for the truck to offload the shipment. However, before the truck parked at the dock, the storekeeper collected a copy of the shipment documents from the truck driver, and he started the inspection procedures. First, he inspected the container's outside condition to make sure it was free of damage and it's sealed well. If the container/truck contained frozen or chilled items, the storekeeper checked the internal temperature of the container/truck from the external temperature monitor display attached to the external body. The internal temperature must comply with Speedy's safe food storing standards. For frozen products, the internal temperature must be around -18 °C. For chilled products, the temperature can be set between 1-3 °C. And for the ambient products, the temperature should be in the range of 22-24 °C. The storekeeper did not rely on the attached temperature monitor only; he inspected the temperature again using his own temperature monitor to confirm the temperature after opening the sealed doors. Fortunately, no case was reported of an noncompliant temperature during Q1-2021. Speedy's suppliers are following the best practices in supply chain management. Thus, the trucks they sent and the containers they shipped were always in good condition and functioning well.

The previous paragraph explains the process of inspecting the container/truck when arriving at Speedy's warehouse. If the inspection went well and the shipment was good to receive, the offloading process started using the walkie-pallet jacks, where the receiving team moved the pallets into the marshalling area. The Quality Inspection Program (QIP) then started with a random selection of two cases from the beginning, two from the middle, and two from the end of the shipment. The storekeeper inspected the temperatures of the selected cases. In addition, the storekeeper inspected the quantity and expiry date information against the supplier's invoice. In the case of any variance or damage in the received shipment, the variant/damaged items should be kept away in a designated area for investigation and insurance claims. The received items then moved to the next step, the put-away. However, in some cases, the received items did not comply with Speedy's pallet standards. Therefore, the receiving team worked on palletising the items again according to Speedy’s standards. This step required much time and effort as the team had to disaggregate items and recompile them in new pallets. That means they had also to wrap the new pallets and stick the detail labels on the pallet sides before they entered these details in the system.

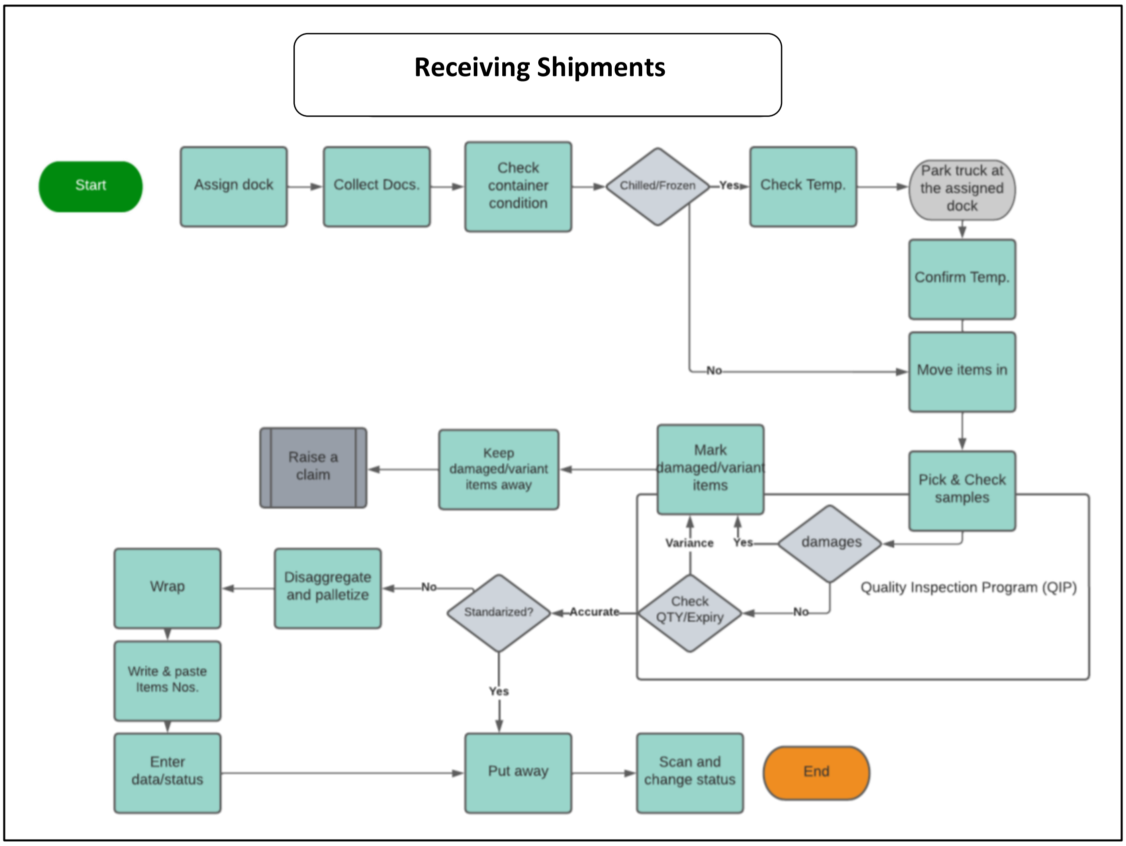

Figure 6-5: The Receiving Shipments activity flowchart

Once the receiving team completed the inspection and palletisation process, the storekeeper entered the pallets detail and updated the shipment status in the warehouse management system (WMS) that Speedy used. Next, the put-away process started with moving pallets away from the marshalling area to the racks, using forklifts. As might be expected, the racks were distributed in the warehouse floor in multiple isles and sections. Each rack had multiple levels, and each level had a unique number presented in a barcode format labelled and stuck on it. The forklift operator used the WMS handheld device (Figure 6-6) to identify the available locations and to occupy them with the new pallets. To assign the location to that pallet, he scanned the location barcode when he put the pallet in. After that, the operator changed the status of the pallet in the WMS from Stage Status to Received, which means this pallet was ready for new sales transactions. Finally, the shipment status must be closed in the ERP system by creating the Goods Receiving Note (GRN). The SCS handled this step by entering the received quantity in the system to allow the finance department to calculate the cost of shipment, which will be discussed in more detail in the Costing section. Table 14 in Appendix B summarises the steps and durations.

Figure 6-6: WMS handheld device

Warehousing

Speedy stored its customers' products in Dammam, Riyadh, and Jeddah warehouses. In Dammam City, there were two warehouses. One had three sections for frozen, chilled, and ambient items, while the other had only one section, for ambient items. The former was owned by the group company that owns Speedy. The other one was owned by a third party that charged Speedy a fixed amount per year for a fixed capacity (number of pallets). In Riyadh City, there were also two warehouses with same arrangement as in Dammam warehouses. However, in Jeddah there was only one warehouse, which the group company owns, consisting of three sections. In addition to those facilities, there were other multiple supporting warehouses in each city that Speedy utilised when there was insufficient storage space in the operating warehouses. The supporting warehouses were rented through third parties who charged based on the number of pallets. Speedy did not use these warehouses as fulfilment centres. Instead, they were only warehousing facilities that supported the main warehouses when needed.

Costing

Speedy dealt with its 4PLs customers, including Hummy, as a seller and logistics services provider. Accordingly, Speedy brought raw materials, finished goods, and packaging items from its customers' suppliers and stored them in its nationwide warehouses. These items were then sold and shipped to Speedy's customers at a specific and predetermined mark-up. From Speedy's point of view, that mark-up represents the profit margin it gains from the logistics services operation; it represents, from the customer's perspective, the saving that occurs in its operating expenses were it otherwise to operate the logistics activities in-house. Therefore, it's vital to practice the OBA between Speedy and its customers to disclose information, especially those related to the cost of products and the landed cost. This strategy allows suppliers (Speedy) and customers (Hummy) to cooperate more transparently and trustfully.

When a new shipment arrived at Speedy's warehouse, and after the shipment receiving process ended, the finance department started calculating the product cost plus the landed cost for that shipment to update the average value of each SKU. For example, suppose a new shipment with 2000 cases of sliced cheese arrived at the cost of SAR 20 per case, and the average value of that item in the system was SAR 15 per case at the level of 1000 cases. In that case, the new value of this SKU in the system will be updated to SAR 18.33 per case at the level of 3000 cases [(2000x20) +(1000x15)/3000). This method is well-known in cost accounting as the weighted average cost, which is one inventory costing method. That was precisely what the finance team did when receiving a new shipment. However, it may be asked what cost items will be included in this calculation. The answer is that the value of any SKU in Speedy's system included the following items: original purchasing cost, custom and clearance charges, management fee, insurance, and bank fees. Except for the original purchasing cost, all other cost items are called the landed cost, which refers to the costs occur after the purchase transaction.

As mentioned in a previous section, the SCS closed the new shipment receiving processes by creating the GRN against the actual quantity received. However, this GRN remained unconfirmed until the finance department finished the calculation of the new shipment values. Therefore, the SCS handed the shipment documents to the finance department to confirm the GRN and calculate the shipment values. When the accountant finished calculating the new value, he confirmed the GRN by entering the new values in the system to again enable the items for sales, which was disabled during this process. When the items became enabled, the SCS was able to process the new sales transactions with the new sales prices. However, to confirm the GRN, the accountant needed approval from the finance department manager first. Therefore, the accountant exported the new items report that contained the items' SKUs and values (cost and mark-up) and sent it to the finance manager through email. The finance manager reviewed the report and approved it if there were no material issues. Figure 6-7 summarises the costing process, and Table 15 in Appendix B summarises the steps durations.

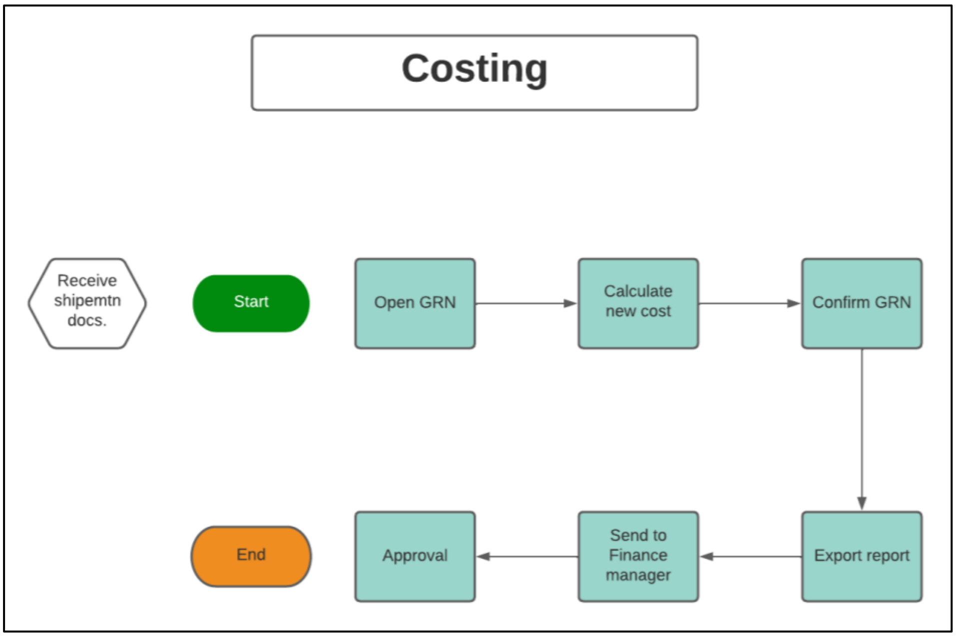

Figure 6-7: The Costing activity flowchart

Claims Management

As a part of any business, the risk of damage is always there, especially when the business relies on multiple suppliers worldwide. Speedy is not an exception. It imports products on behalf of Hummy from several suppliers, overseas and locally. Transit times, customs procedures, deliveries accidents are threatening factors that may cause losses to Speedy. Therefore, Speedy had agreed with Hummy to insure the new shipments and include the cost of insurance within the products total cost. This agreement protects Speedy from any losses due to damages to the new shipments. The most frequent reason behind damages is the custom inspection procedures. When containers arrive at the borders, the customs officer, as a part of his job, inspects a few samples from the container to make sure it's safe and matching with the disclosed shipment information. Those inspected samples usually become unsuitable for sale, especially since many are chilled or frozen items. Another damage cause is poor packing or unsafe handling. Some items are fragile; thus, they need more attention when handling and shipping. Although this scenario is rare at Speedy as it deals with professional suppliers and consolidators, the first scenario happened almost with every shipment arriving overseas. The following paragraph explains the procedure when a new shipment arrived with damaged items.

As mentioned in a previous section, the new shipments were inspected through a well-designed QIP once they arrived at the marshalling area. The damaged items were separated from the rest, and the storekeeper recorded the damaged quantity on the shipment advice. The warehouse data-entry specialist then received the shipment advice and started the damage claim process, as Figure 6-8 shows, by entering the claim detail in the company ERP system. Next, he shared the claim report with the finance department, which is responsible for the claims management with the insurance company. The finance team evaluated the damaged items' value in the system. Speedy can't raise claims to the insurance company unless the value of the damaged items is more than SAR 1250. Speedy can't raise the claim to the insurance company if the damaged item value is below that limit. Instead, it covered the damage losses through a provision account in its accounting system that covers such claims. The provision cost was already allocated to the Hummy products while calculating the cost of the new shipments.

If the damaged item value was equal to or less than SAR 1250, Speedy's storekeeper, controller, and one worker destroyed the damaged items and wrote them off the system. If the damage value was more than SAR 1250, the finance team prepared the claims documents and had them signed by the finance manager before sending them to the insurance company. This step happened once a month, including all claims of the previous month. Then, the insurance company sent the Form of Acceptance (FOA) to the finance team to agree and sign. The insurance company sent a representative to Speedy to inspect and destroy the items. After that, Speedy received the claim amount through a bank transfer from the insurance company. Table 16 in Appendix B summarises the Claims Management activity steps and durations.

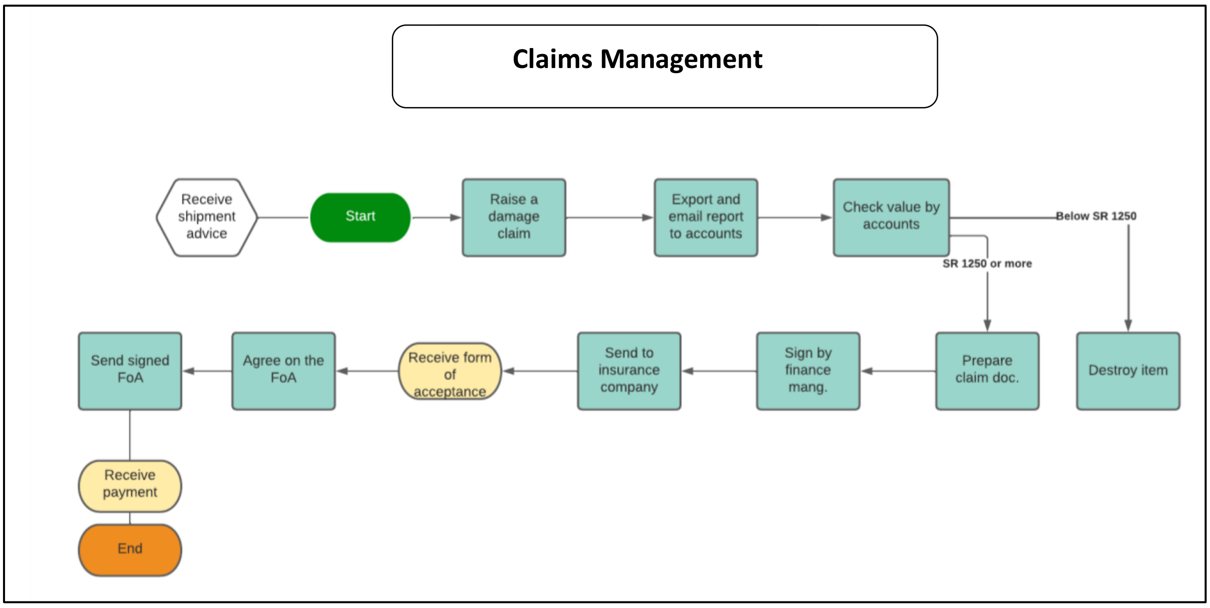

Figure 6-8: The Claims Management activity flowchart

Branch Transfers

Speedy transferred Hummy's stock among the five operating warehouses in the three cities to meet the demand from Hummy’s branches. When new shipments arrived from suppliers, they arrived either at the central warehouse in Dammam City, mostly, or the Jeddah warehouse. The SCS then studied the quantity on hand for all SKUs in each warehouse. He also studied and reviewed each warehouse's sales reports for the last four weeks to determine the consumption rate per SKU. The results of these studies helped him divide the quantity received in the new shipments among the different warehouses on an informed basis. When the supervisor came up with the transfer plan, he checked with the transportation department for the next available trip. For branch transfers, Speedy used 24-pallet-length trailers to distribute stock among warehouses. The trips were not dedicated to Hummy's stock transfers only but to all customers' stocks. When the next available trip was arranged with the transportation department, the supervisor raised the transfer-Oot request on the ERP system. Each request was for only one receiving warehouse. For example, if a shipment had to be transferred to two warehouses, each warehouse needed a separate transfer-out request.

Next, the supervisor emailed this transfer-out request to the storekeepers of both the sending and receiving warehouses. The sending warehouse storekeeper printed out the request and started the collection process. The Picking & Loading process will be explained in a following section. Once the shipment was loaded in the trailer, the trailer driver signed the document and left the location. During the transit time, the supervisor checked the transfer status with the driver and storekeepers. When the shipment arrived at the receiving warehouse, the receiving team worked the same way as receiving new shipments. The receiving warehouse's storekeeper then created the transfer-in request data in the ERP system to reconcile with the open transfer-out request. By doing this step, the transfer request was considered complete, and the receiving storekeeper confirmed that by emailing both the SCS and the sending storekeeper. Finally, the Branch Transfer transactions were not limited to distributing new shipment stock. Sometimes, a shortage in specific SKUs in one warehouse raised the need for replenishments from other warehouses. The SCS, thus, was responsible for checking the quantity of all SKUs across the warehouses to ensure decent levels of stock in each. Figure 6-9 visualises the Branch Transfer activity flow while Table 17 in Appendix B summarises the steps and durations for this activity.

Processing Orders

Next, sales and distribution; Hummy's outlet managers sent orders to Speedy's SCS through emails, daily. The customer sometimes called for urgent orders, but that was not acceptable at Speedy, where they required the customer to officially email requirements instead. The orders came in the early mornings or afternoons. If the order came in the early morning, the supervisor processed it immediately, so the operation team prepared it for delivery on the same day. If the order came in the afternoon, the delivery was delayed to the next morning. The orders came from customers in an Excel format. The supervisor entered the order detail into the ERP system that generated a sales order document. That document went to the customer (the outlet manager and the supply chain team at Hummy) as a confirmation document from Speedy. Another copy went to the storekeeper by hand to start collecting and preparing the shipment for delivery. When the order came from Hummy's outlets in Riyadh or Jeddah cities, the supervisor emailed the storekeepers in Riyadh and Jeddah with a copy of the sales order. See Figure 6-10 for the Processing Orders activity flowchart and Table 18 in Appendix B for the steps and durations.

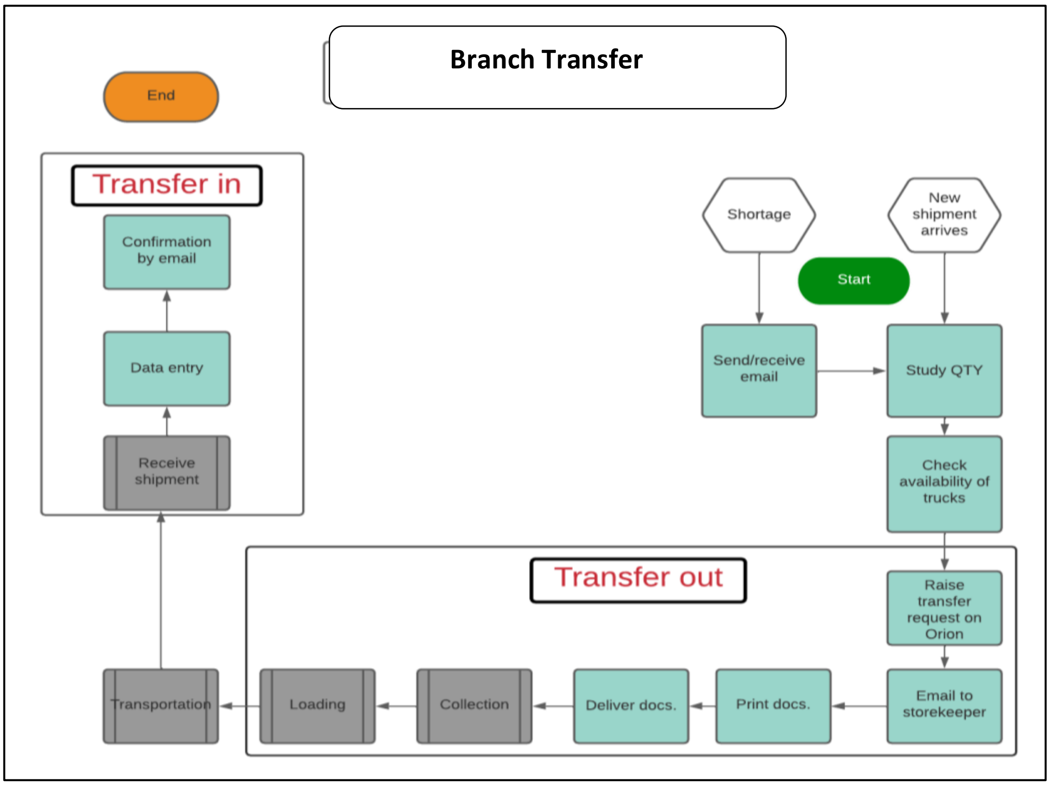

Figure 6-9: The Branch Transfer activity flowchart

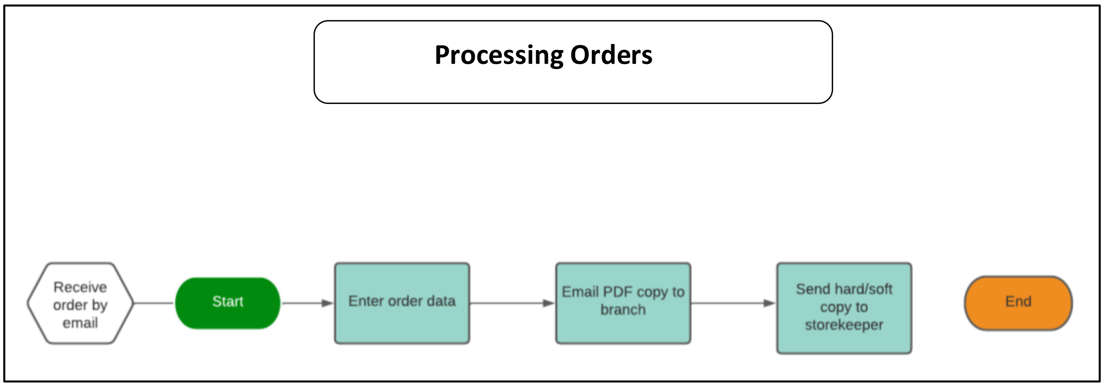

Figure 6-10: The Processing Orders activity flowchart

Picking & Loading

Speedy followed the best practices in supply chain management and adapted best-of-class technology to ensure smooth and efficient operation. For example, it used the WMS, including handheld devices, that help manage stock control and operation. However, this technology was not free of charge or, at least not cheap. According to the operation manager, Speedy had to pay an extra cost if it needed to add a new customer to its WMS. Therefore, Speedy and Hummy agreed not to add that extra charge and to operate and manage the warehouses more traditionally. Although it was mentioned in a previous section that the WMS is being used when receiving new shipments, the Picking & Loading processes for Hummy's orders relied on manual work by the storekeepers and workers. For example, in the case of customers who agreed to pay for the WMS fees, the orders went to the storekeeper through the ERP system, and he then generated the picking list that showed the items' locations and more detail. In contrast, in Hummy's case, the orders went to the storekeepers manually or through emails as a PDF copy. The storekeepers then handed that copy over to the pickers, who needed to find the locations manually.

In standard settings, the storekeeper and one or two pickers were involved in the Picking & Loading processes. The pickers first brought an empty pallet using a manual hydraulic jack. Then, they started picking the items against the sales order document. As mentioned previously, Speedy had three different sections for ambient, chilled, and frozen items in most warehouse facilities. Hummy's orders often contained products from all three types. Therefore, the collection started with the ambient items first. Next, the storekeeper went to the chilled and frozen warehouses to hand the sales order to the workers to pick up the chilled and frozen items. The pickers who worked in the chilled and frozen items differed from those who worked in the ambient warehouse as the temperature in the chilled and frozen warehouses was low (down to -24 °C), which required special jackets and clothing.

Once the items were picked from all three sections and became ready in the pallets, the consolidation process started in the marshalling area under the supervision of the storekeeper. The storekeeper had to inspect and quantify all items in the presence of the truck driver who delivered the orders to branches, as he had to sign on the sales order document that he had received the exact quantity in good condition. If the order contained mixed products from ambient, chilled, and frozen items, the ambient items had to be palletised separately from the chilled and frozen. Next, the pallets were wrapped manually before loading. Meanwhile, the driver brought the truck to the warehouse dock. The storekeeper had to check the truck temperature to ensure that it was proper for the order items' temperature (e.g. -18 °C if there were frozen items in the order). Once the storekeeper confirmed the temperature, the picker loaded the pallet inside the truck, and the driver left the warehouse to the customer's location with the orders and documents. Figure 6-11 depicts the flow of process of Picking & Loading activity while Table 19 in Appendix B summarises the times of steps.

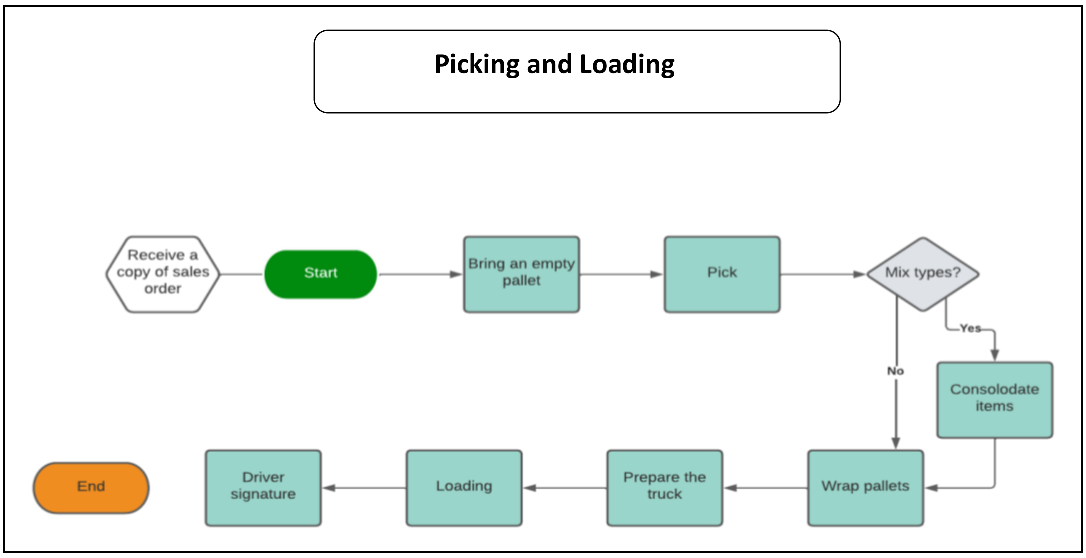

Figure 6-11: The Picking & Loading activity flowchart

Delivery

The order was loaded and positioned on a cooling truck. Speedy used a divider wall to separate the pallets that contained ambient items from the chilled and frozen ones. The pallets for the chilled and frozen items were positioned at the front of the truck close to the cooling unit, while the ambient items' pallets were positioned at the back of the truck close to the door. This helped keep the temperature in the chilled and frozen section down with no damage to the ambient items. The truck transited from Speedy warehouses to Hummy's outlets directly as the trucks were dedicated to Hummy only. The transit time varied depending on the route plan, which will be discussed in the next paragraph. When the truck arrived at Hummy's outlets, the driver approached the branch manager directly with the sale order document to prepare for offloading. The restaurant workers cooperated with the driver, who provided the required equipment, such as the jack, in the offloading process. When the offloading process ended, the driver prepared the truck for leaving to the next step if there was another outlet in the plan, or back to the warehouse. Upon arrival at the warehouse, the driver handed the sales order document to the data entry team who updated these orders in the company's ERP system.

In Q1-2021, Hummy had seven restaurants scattered in three Saudi cities: 4 in Riyadh, 2 in Jeddah, and 1 in Dammam City. Speedy dedicated four trucks to deliver the orders to Hummy's restaurants: two in Riyadh, one in Jeddah, and one in Dammam. According to the transportation department manager, Speedy used its own truck in Dammam for delivery, while it used third-party trucks in Riyadh and Jeddah. According to the SCS, the route plans in all three cities were fixed all the time. In Dammam and Riyadh, the onloading process started from the internal warehouse first before the trucks went to the external warehouse. In Jeddah, as there was no external warehouse, the process started from one warehouse, which was the internal warehouse. Table 20 in Appendix B demonstrates the route plans for the 4 trips in the three cities. The total destination column shows the total number of kilometres that each truck travelled every day. This number includes the return distance as well. If the trip included more than one restaurant, which was mostly, the cost of total distance was allocated to the two restaurants equally. Figure 6-12 visualises the flow of Delivery process while Table 21 in Appendix B summarises the durations of the steps.

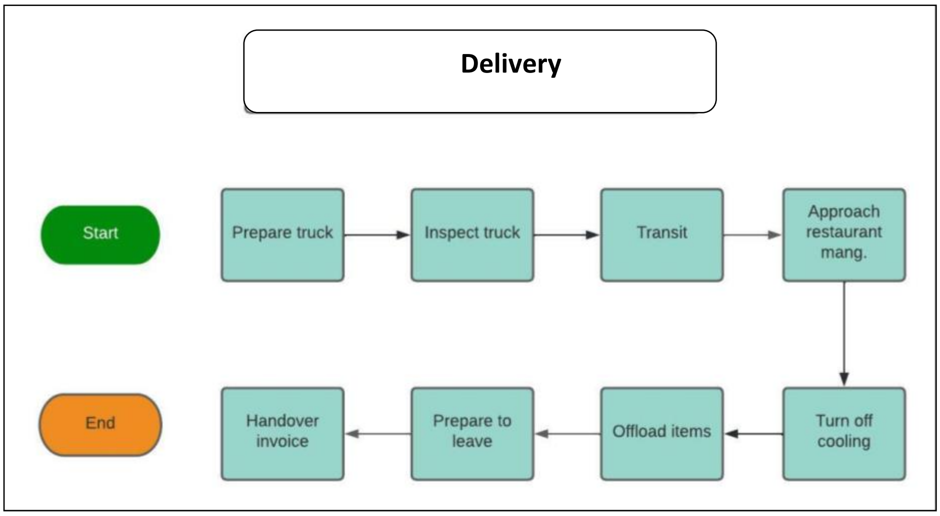

Figure 6-12: The Delivery activity flowchart

Invoicing

At the beginning of each month, Speedy's finance team prepared a report for Hummy's management that contained the sales transactions per outlet during the past month. Hummy then paid Speedy the total amount for all outlets' sales. As usual, the payment came in one transaction, If the total amount was less than one million Saudi Riyal. Otherwise, the remaining amount that exceeded one million came in another transaction due to bank transfer limitation. When receiving the payment in Speedy's bank, the finance team prepared the receiving voucher for each outlet separately, so the accountant matched those vouchers with the sales invoices. In the end, the system processed these vouchers and reconciled them with the sales transactions. See Figure 6-13 for the Invoicing flow chart, and Table 22 in Appendix B for the duration of the steps.

Step six: Time Equations Development

In the preceding sections, we have calculated the CCR per each resource pool, and discovered the processes of the 11 supply chain and logistics services that Speedy provided to Hummy. Next, it is time to develop the equations that calculate the cost of those services according to the TD-ABC methodology.

Product Registration

As mentioned earlier, the product registration service was needed when importing a new product for the first time to Saudi Arabia or when an existing product's information or facts changed. In Q1-2021, there were five amendments to five products' information, requiring changes to the existing information on the SFDA system. Fortunately, since these changes were not affecting the existing products designs, there was no need to redesign the product artwork, which is the bottleneck of this service process. Speedy, in addition, did not have to enter the new data in the SFDA portal. Instead, this step was outsourced to the group company that owns Speedy, which had a dedicated team for product registration for all operating companies under its umbrella. That leads us to conclude that this service's cost is limited to collecting and forwarding data from the customer to the group company's team, which takes only one minute. Accordingly, the researcher developed a straightforward time equation for this service:

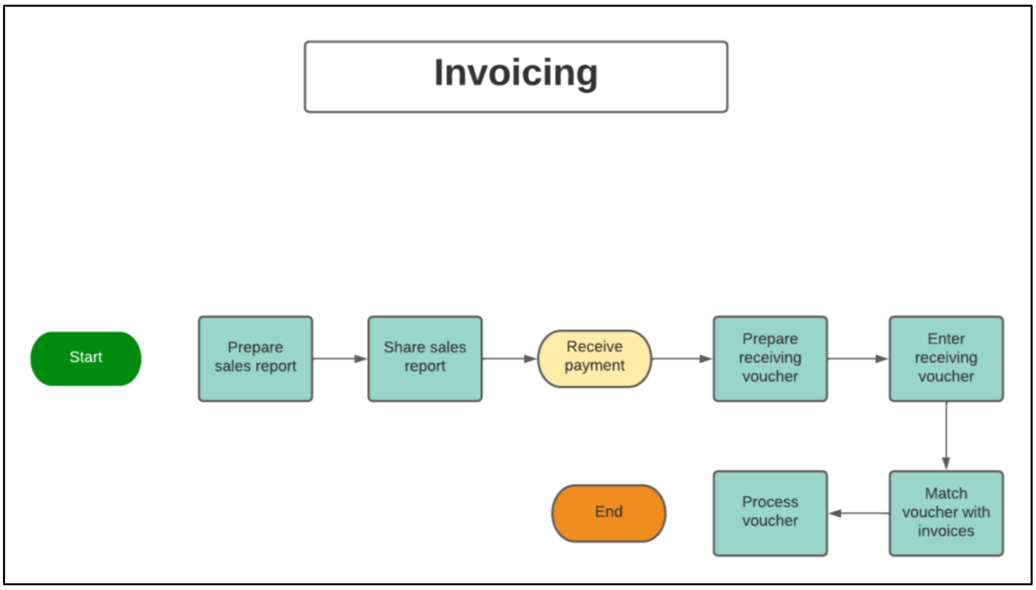

Figure 6-13:The Invoicing activity flowchart

Product registration (minute) = 1 X # of products +

(if design needed, 30 X # of designs, 0)

Equation 6-66-1: Product registration TD-ABC time equation

Table 23 in Appendix B shows the record of product registration transactions in Q1-2021 and the associated cost. It can be seen that this activity is not a major one in terms of the time and cost required from Speedy. The total time spent on this activity during the entire quarter was only 5 minutes representing five emails sent from the supply chain supervisor to the registration team at the parent company.

Demand planning

In Q1-2021, Speedy's SCS conducted 13 plans to project future demand for Hummy's 61 products. As depicted in the Demand Planning activity flowchart, the Demand Planning activity required a few steps to generate one plan. According to these steps, Equation 6-2 shows the TD-ABC formula for this activity.

$$\text{Demand planning (minute)} = 3.5 + (\text{\# of SKU X } 3.5) + (\text{if consolidation required, } 1 + (\text{\# of items X } 0.25), 0)$$

Equation 6-2: Demand planning TD-ABC equation

Equation 6-2 shows that the standard time to develop one plan is 3.5 minutes. In addition, this activity required another 3.5 minutes per each registered SKU. The SCS had to conduct his projections to all 61 registered SKUs. In the case this activity resulted in the recommendation of buying multiple items from multiple suppliers in one country, the SCS needed an additional 1.25 minutes per SKU to plan for the container capacity that consolidated the items. However, this situation was not recorded in Q1-2021. Thus, this part of the equation was always equal to zero. Table 24 in Appendix B shows the number of demand plans for the 61 registered SKUs during Q1-2021. From this table, someone can infer that the SCS implemented this activity weekly, almost, where 5, 4, and 4 plans were generated in Jan, Feb, and Mar, respectively.

By applying the demand planning equation above to the data extracted from Q1-2021 records, we can calculate the total cost of this activity that occurred in the same period month by month; see Table 25 in Appendix B. This activity showed high consistency in the cost of implementation month by month as the cost was dependent on one variable, which is the number of SKUs.

Procurement

Speedy handled procuring Hummy's products from pre-specified local and international suppliers. This service was seen as one of the most valuable services that Speedy offered. It consisted of 17 steps, as the Procurement activity flowchart shows in Figure 6-4. Some of these steps were handled by the SCS, some by the finance team, and some were outsourced to external parties. The researcher developed two equations (see Equations 6-3 and 6-4) that can capture the complexity of this process. While Equation 6-3 captured the processing time of this activity in the HED-SC resource pool, Equation 6-4 calculated the time for payments to suppliers or for the customs duty, which were handled by the finance team HED-AC. These two equations incorporate multiple variables such as the location of suppliers (local vs international), type of goods purchased (food vs non-food items), and the type of suppliers (new vs existing).

Procurement in HED-SC (minute) = 12 + (0.75 X # of products) + (if international vendor, 9, 0) + (if food items, 3 X # of

Equation 6-4: Procurement TD-ABC equation – HED-SC resource pool

Procurement in HED-AC (minute) = 2 + (if an international vendor, 1, 0) + (if a new supplier, 3, 0)

Equation 6-4: Procurement TD-ABC equation – HED-AC resource pool

By applying the two equations above to the operational transactions that took place in Q1-2021 (see Table 26 in Appendix B), we can see that the total cost of this activity was SAR 556 in the entire Q1-2021. This cost was derived from two resource pools where most of it was generated from the supply chain department HED-SC engagement (93%), and the remaining 7% was generated by the finance department HED-AC. Tables 27 and 28 in Appendix B set out the time spent and the cost of Procurement activity in the HED-SC and HED-AC resource pools, respectively, while Table 29 in Appendix B shows the total cost combined from those two pools.

Receiving shipments

During Q1-2021, Speedy received 15 shipments from Hummy's suppliers. Table 30 in Appendix B shows the number of received shipments, items, and cases each month. Tables 31, 32, and 33 in Appendix B elaborate more on the type of products received and the number of equivalent pallets, which were calculated using the dimensions of each product in CBM each month in Q1-2022.

Accordingly, the time equation was developed to capture the variations in the number of equivalent pallets, the number of cases received, and the type of items. Equation 6-5 below was developed for this purpose. You can note that the warehouse location was always in one of the Dammam warehouse facilities (frozen, chilled, ambient, or external). That means that all shipments received in Q1-2021 were received in the Dammam facility, and no shipments were received in either Riyadh or Jeddah.

If ([WH_LOCATION] == DMM-WH-F or DMM-WH-C, if ([Storage_Type] ==FROZEN or CHILLED, 12 + 10.42 * [Equivalent_Pallets] + + if ([Damaged Items] == YES, (4.05 * Damaged_cases),0) + if ([not palletised] == YES, (9.3 X # Of pallets) ,0) + if ([WH_LOCATION] == DMM-WH-A or DMM-WH-E, if ([Storage_Type] ==AMBIENT, 5 + 10.42 * [Equivalent_Pallets] + if ([Damaged_Items] == YES, (4.05 *Damaged_cases), 0) + if ([not palletised] == YES, (9.3 X # Of pallets), 0)

Equation 6-5: Receiving shipments TD-ABC equation

By applying the previous equation on the operational record for this activity in Q1-2021, we can calculate the cost of receiving shipments according to the TD-ABC methodology, as Tables 34, 35, and 36 in Appendix B show. Although Speedy received the same number of shipments every month in Q1-2021, the cost of receiving shipments varied significantly month-to-month. In February, for example, the total cost was SAR 2,959, while it was only SAR 558 in March. Although the number of shipments is identical in both months, this variation in the total cost indicates that the TD-ABC equations succeeded in capturing the detail of each shipment, such as the number of equivalent pallets received.

Warehousing

This service is unique and different from other services discussed here. That is because it does not contain any process flow. Consequently, there is no processing time involved. Instead, the cost of this service was calculated based on the number of CBMs consumed by Hummy's products from the available capacity in each warehouse. As mentioned earlier, Speedy did not use the WMS solution for Hummy's business. This constituted an obstacle for the researcher in calculating the day-to-day storage cost. Products moved in and out daily. Therefore, the researcher used the average holding days per SKU to calculate this cost. When a product moved out for delivery, the researcher took the total CBM moved out from that SKU, multiplied it by the average days of holding, and multiplied it by the cost per day for that product's storage type. For example, if 1 CBM of product A was ordered today, and if the average holding days for product A was 30 days, and if product A was stored in the frozen storage, the researcher calculated the cost of storage for that item as follows; 1

X 30 X CCR for that storage. Tables 37, 38, and 39 in Appendix B show the available capacity during Q1-2021, the capacity consumed by Hummy monthly, and the total cost for each warehouse in the three cities. From the tables, we can see that Hummy's products occupied between 3.7 to 4.6% of the total warehouse capacity and that occupancy cost between SAR 34,000 to SAR 44,000, approximately. This was the highest among all supply chain services and logistics costs in Q1-2021. Also, we can see that the cost of storing frozen items was the highest among the three types of products. This type occupies more space than the other types in Speedy's warehouses.

Costing

As mentioned earlier, the costing process started immediately after receiving new shipments from suppliers. This process was owned by the finance team only (HED-AC). Equation 6-6 formulates the time needed to perform one costing activity for one shipment. The equation shows that the costing process takes 14.5 minutes per shipment plus 1 minute per SKU inside that single shipment. That means if we had one shipment with one single item, we'll need 15.5 minutes to perform costing, which would cost Speedy SAR 13.485 in Q1-2021 (15.5 minutes multiplied by the CCR for the finance department, which was 0.87). Table 40 in Appendix B shows this activity's total time spent and cost in Q1-2021.

The total cost of this activity in Q1-2021 was SAR 242.22. January and March had similar cost numbers (SAR 87.40 each), and February had a lower number (SAR 67.42). Although the Costing activity was triggered by the Receiving Shipment activity, the cost behaviour of both activities differed. As seen in the Receiving Shipment activity, the cost in February was the highest (SAR 2959.40), while the lowest cost was in March (SAR 558). Also, there was no similarity between the cost numbers for any two months. In Costing, the similarity between January and March cost numbers was observed, and February had the lowest cost number among the three months. These differences in the cost behaviour between the two activities reflected that the TD-ABC methodology could capture the complexity of activities by using time as a cost driver rather than the number of transactions. Both Receiving Shipments and Costing activities had the same number of transactions (5 events per month in Q-2021). However, the time equations captured more details from both activities' processes, such as the number of SKUs and the number of cases in each shipment received. Such depth in detail helped the cost system to generate more realistic outcomes.

$$\text{Costing (minute)} = 14.5 + (1 \text{ X } \# \text{ of SKUs})$$

Equation 6-6: Costing activity TD-ABC equations

Claims management

This activity was one of those activities owned by multiple teams (resource pools). The operation team at the receiving warehouse, mostly "DMM-LB", and the finance team "HED-AC" shared the responsibility of this activity where each team handled some steps. Thus, two cost rates were embedded in two equations (6-7 and 6-8) to calculate this activity's cost.

Claims management at "HED-AC" (minute) = 5 + (2 X # of items) + (if above value limit, 14, 0)

Equation 6-7: Claims management TD-ABC equation – (HED-AC)

Claims management at "DMM-LB" (minute) = 2 + (10.08 X # of items)

Equation 6-8: Claims management TD-ABC equation – (DMM-LB)

The probability of receiving damaged items at Speedy was low. During Q1-2021, there were only seven damage incidents reported by the operation team to the finance team, as Table 41 in Appendix B shows. Not all damages were reimbursable; the insurance company has a minimum value for the claimable damages. Accordingly, this activity's performance duration depended on this rule. In Q1-2021, there were only two claimable incidents, while the other five were closed internally. Tables 42, 43, and 44 in Appendix B demonstrate the standard time needed to perform all steps of this activity per each team (resource pool) and the allocated cost in Q1-2021 according to Equations 6-7 and 6-8. The calculation results show that this activity had a low impact on the total cost of integrated supply chain activities, where the total cost in Q1-2021 was only SRA 147.84.

Branch Transfer

As explained in the Branch Transfer process in Section 1.2, Speedy transferred stock between its five facilities in three cities to ensure availability from each SKU when ordered. This activity required two types of resources, FTEs and trucks. The SCS initiated the process; the sending warehouse team picked and loaded shipments; drivers transported them to destinations; and the receiving warehouse team received and put the items away. Consequently, a single equation can't capture this activity's cost. Multiple equations were needed to reflect the long process and different CCRs. In short, the total cost of this activity should include the following elements:

1. SCS's cost (HED-SC)
2. Warehouses teams' cost (DMM-LB), (RYD-LB), or (JED-LB)

3. Drivers' cost (DMM-DR), (RYD-DR), or (JED-DR)
4. Trucks cost (DMM-TR), (RYD-TR), or (JED-TR)

The supply chain supervisor processed 53 transfer requests during Q1-2021 for 259 items. Each request required 8.9 minutes plus 0.06 minutes per item. The TD-ABC equation for this part of the activity's cost was simple, as shown in Equation 6-9 below. Accordingly, the total cost of this resource pool (HED-SC) for this activity was SAR 301.61, as demonstrated in Table 45 in Appendix B.

$$\text{Branch transfer at HED-SC (minute)} = 8.9 + (0.06 \text{ X \# of items})$$

Equation 6-10: The TD-ABC equation for Branch Transfer activity (HED-SC)

The sending warehouse team had to pick up and load items on the truck. This process was identical to Picking & Loading when receiving sales orders. In Q1-2021, 53 transfer requests were lodged from multiple locations, as Table 46 shows in Appendix B. Accordingly, the TD-ABC equation had to capture this by considering the CCRs associated with each location. For Dammam and Riyadh's internal and external warehouses, the labour cost was combined in one resource pool in each city. For example, Dammam's internal and external warehouse labours were allocated to the DMM-LB resource pool. That is because labourers were rotated between warehouses daily depending on the workload and circumstances and shared the same resources. Therefore, we had only three resource pools for the five locations mentioned in Table 47, Appendix B, and these pools were DMM-LB, RYD-LB, and JED-LB. Equation 6-10 below was developed to calculate the cost of Picking & Loading items for the Branch Transfer activity and other similar activities in each resource pool. Table 47 in Appendix B shows the results of applying Equation 6-10 on the operational record in Table 46, Appendix B.

$$\text{Picking \& Loading (minute)} = 10.75 + (5 \text{ X \# of cases}) + (3.5 \text{ X \# of equivalent pallets})$$

Equation 6-9: The TD-ABC equation for Picking & Loading activity in DMM-LB, RYD-LB, or JED-LB

Each transfer request had two ends, sending and receiving. Speedy recorded this in its system with the labels transfer-out and transfer-in. While the sending warehouse team performed Picking & Loading activities, the receiving warehouse team had to receive and put away shipments. The previous part demonstrates the process of picking loading items for the transfers-out. The transfers-in process is similar to what was explained in the Receiving Shipment activity, where it ended up with 12 minutes per shipment plus 10.42 minutes per pallet. Tables 48 and 49 in Appendix B show the operational records and the cost of transfer-in activities in Q1-2021.

The researcher analysed the transfer requests processed in Q1-2021 to clearly understand how these requests consumed the transportation department's resources. The transportation department had two main resources, trucks and drivers. Tables 50, 51, and 52 in Appendix B show the details of Branch Transfer trips completed in January, February, and March 2021, respectively. Before that, it's essential to understand the location codes in the tables below. These codes are:

- 002: Dammam internal warehouses (DMM-WH-F, DMM-WH-C, and DMM-WH-A)
- 205: Dammam external warehouse (DMM-WH-E)
- 004: Riyadh internal warehouses (RYD-WH-F, RYD-WH-C, and RYD-WH-A)
- 419: Riyadh external warehouse (RYD-WH-E)
- 003: Jeddah internal warehouses (JED-WH-F, JED-WH-C, and JED-WH-A)

From the record of transfer requests above, we can infer that three main variables control the cost of this activity: the distance between the origin warehouse and the destination the driving time for that distance, in minutes, and as Speedy transported stock for multiple customers, including Hummy's stock, in one trip, the space that Hummy's products utilised from the total available capacity on the truck was also an essential variable as we need it to allocate the cost accordingly. Speedy used 24-pallet-length trailers to transfer stock between its locations for customers, giving 29.76 CBM in capacity (1.24 CBM for standard pallet size multiplied by 24). According to the three aforementioned variables, the TD-ABC equations were developed to capture the cost of transferring Hummy's product, see Equations 6-11 and 6-12. Tables 53 and 54 in Appendix B show the total cost for this activity for Hummy's product transfers and for all transfer requests incurred in Q1-2021 for all customers including Hummy. Next, the researcher used the space utilisation percentage as a cost driver to determine how much cost should be allocated to Hummy's product transfers. Tables 55 and 56 in Appendix B show the result of this allocation for both truck and driver costs.

Drivers' cost (Branch transfer) = CCR (n) X driving time (min) X capacity utilisation

Equation 6-11: TD-ABC equation for Branch Transfer activity (drivers cost)

Trucks cost (Branch transfer) = CCR (n) X destination in km X capacity utilisation

Equation 6-12: TD-ABC equation for Branch Transfer activity (truck cost)

Processing Orders

The SCS at Speedy received at least seven sales orders daily from Hummy's seven branches in Saudi Arabia. Some days, one branch sent more than one sales order. The SCS processed the orders in the company's ERP system to record the sales and trigger the Picking & Loading process. The time needed to perform this activity depended on the number of items ordered. However, this variable was not influential unless the order had tens of items. On average, each order needed 3.8 minutes plus 0.05 minutes per each item ordered. Equation 6-13 depicts this activity's duration for the TD-ABC model. Table 57 in Appendix B shows the sales orders in Q1-2021 and the total monthly cost. The table shows that the total cost for this activity was SRR 2,484.10, which was the supply chain department's most costly and time-consuming activity. It counted for 50 to 70% of the total time consumed in Q1-2021 for Hummy's operation.

Order processing (minute) = 3.8 + (0.05 X # Of items)

Equation 6-13: TD-ABC equation for " Processing Orders" activity

Picking & Loading

The Picking & Loading activity was discussed partially in the Branch Transfer section. However, in this section, the researcher shows the Picking & Loading cost related to the sales orders. In Q1-2021, Hummy's branches placed 979 orders with 5854 items. The system generated orders and sent them to the operation teams in 979 picklists. The operation teams in the five different warehouses picked more than 13,000 cases. Equation 6-14 for this activity is identical to what was used in the Branch Transfer activity equation:

"Picking & Loading" (minute) = 10.75 + (5 X # of cases) + (3.5 X # Of equivalent pallets)

Equation 6-14: TD-ABC equation for Picking & Loading activity

By applying Equation 6.14 on the operational record shown in Table 58 in Appendix B, we obtained the total cost per each resource pool associated with this activity. Table 59 in Appendix B shows the final results for this activity per each resource pool. The total cost of the Picking & Loading activity for all three resource pools (DMM-LB, JED-LB, and RYD-LB) in Q1-2021 was SAR 73,838, which was the second highest cost in the entire integrated supply chain activities after Storage activity. By comparing the cost of this activity among the three resource pools that implemented it, we can find that the RYD-LB had, by far, the highest number in all months, where it consumed 31%

more time and cost than the DMM-LB and JED-LB combined. Although this difference between the three locations' costs is enormous, it does not necessarily reflect the actual operational volume differences. The RYD-LB fulfilled 57% more orders than DMM-LB and JED-LB combined. RYD-LB also picked and loaded 45% more cases than the other two pools. Such outcomes may refer to the conclusion that the CCR is a significant determinant of the overall results, where the average CCR in Q1-2021 for RYD-LB was SAR 0.80 compared to SAR 0.87 and SAR 1.16 for DMM-LB and JED-LB, respectively.

Delivery

In Q1-2021, Speedy delivered the 979 orders received from Hummy's branches through more than 300 trips to 7 locations around Saudi Arabia. More than 22,000 km were travelled, and around 40,000 minutes were spent to supply Hummy's seven branches with the needed products. As explained previously, four trips travelled daily or semi-daily from Speedy's DCs to Hummy's branches. Table 60 in Appendix B shows the details of each trip, including the total distance in kilometres, total driving time in minutes, and total cases delivered each month. To calculate the cost of deliveries, the researcher developed two TD-ABC equations that can capture the variations in distance and time among trips. The rationale for dividing this activity’s calculation into two separate equations instead of one is rooted in the fact that trucks have different cost drivers from the drivers of those trucks. While Equation 6-15 calculates the cost of trucks using the distance as a cost driver, Equation 6-16 handles the time side by calculating the cost of drivers when travelling for deliveries. This equation uses time as a cost driver and considers the volume of orders as another source of variation in the cost allocation.

Trucks cost (Delivery) per trip= CCR X destination in km

Equation 6-15:TD-ABC equation for Delivery activity (trucks cost)

Drivers’ cost (Delivery) per trip= 10.75 + (CCR X driving time in min) + (0.366 X # Of cases)

Equation 6-16: TD-ABC equation for Delivery activity (driver cost)

By applying the two formulas above on the four-trip record shown in Table 60 in Appendix B, the researcher calculated the cost of trucks and drivers assigned to each trip, as Tables 61 and 62 in Appendix B suggest. As Table 63 shows, we can see that Trip 2 had the highest cost records in all the three months, although it had a smaller number of trips compared to Trip 3 and Trip 4. That's because the distance travelled in Trip 2 and the high CCR of the JED-TR resource pool played a more impactful role on the cost than the number of trips; thus, they resulted in a cost number twice as high as that allocated to the Trip 3 or Trip 4. On the other hand, Trip 1 had the lowest cost records in Q1-2021, which can be explained by the fact that this trip travelled less distance than all the other three trips. Table 64 suggests that the discrepancies between the resource pool CCRs significantly affected the allocated cost. In the RYD-DR resource pool, the CCR was too low (averaged at SR0.03) compared to the other two pools, DMM-DR (SAR 0.24) and JED-DR (SAR 0.10). This massive gap between the three pools could be attributed to the fact that Speedy relies heavily on third-party services for transportation activities in Riyadh and Jeddah cities, including truck and driver rentals.

The combination of trucks' and drivers' costs for Delivery activity is presented in table 63 in Appendix B. In that table, we can conclude that Trip 2 was the most expensive one in terms of both trucks' and drivers' costs. In Q1-2021, the total cost of Trip 2 was SAR 8466.70, while trips 1,3 and 4 cost SAR 2405, 3827, and 3794, respectively.

Invoicing

Invoicing is the last activity of the integrated supply chain activities that Speedy performs to provide services to Hummy. The finance team prepared the sales record for the past month's transactions at the beginning of each month. In Q1-2021, the record shows 322, 310, and 347 sales invoices generated in January, February, and March, respectively. According to the researcher's observations, the standard time needed to process and share invoices was 7.8 minutes per report plus 0.5 minutes per invoice, see Equation 6-18 All seven Hummy branch transactions were consolidated in one monthly report. That means the finance team prepared and shared one monthly report with Hummy's group management. Table 64 in Appendix B shows the results of this equation application when we used it with the CCR for the finance department HED-AC in Q1-2021The Invoicing activity cost was insignificant in Q1-2021, where the total cost was SAR 446.

$$\text{Invoicing (minute)} = 7.83 + (0.5 \text{ X \# Of invoices})$$

Equation 6-17: TD-ABC equation for Invoicing activity

Step seven: Allocation to Cost Objects

The cost of integrated supply chain activities has been calculated through the previous steps. Now, the final step in the TD-ABC model development process is allocating overhead cost from activities to cost objects, which are customers/branches. The researcher allocated the calculated overhead cost to the seven branches of Hummy in two different methods.

The indirect allocation method

As mentioned in Chapter 4, Case-Study Protocol, branches did not demand some activities directly. Speedy performed some activities for the overall business with Hummy and to fulfil future orders from branches. However, the researcher still had to indirectly allocate these activities' costs to the seven branches of Hummy. Given the absence of a direct cause-and-effect relation between these indirect costs and the seven branches, the researcher used the number of sales orders as a cost driver to allocate the cost of such indirect activities from the group customer to the seven branches. While this allocation may seem simplistic, the researcher believes it to be the most pertinent approach in such scenarios, as the overall business activity was driven by the sales volume. Table 65 in Appendix B shows the number of sales orders placed by each branch in Q1-2021. Based on this table's outcomes, the researcher allocated the cost of the indirect activities, (Demand Planning, Procurement, Receiving Shipments, Costing, and Claims Management) to the seven branches of Hummy as Tables 66, 67, and 68 in Appendix B show in January, February, March 2021, respectively. The results suggest that the Jeddah branches (Branch 2 and Branch 3) had the lowest allocation portions, with 7% and 6% of the total cost, respectively. On the other hand, the other five branches had a similar number of orders in Q1-2021; thus, they had been assigned with similar cost portions ranging from 15-19% of the total overhead cost per branch.

Storage activity cost was allocated similarly to the indirect activities above. However, in the second allocation from the group customer to the individual branches, the researcher allocated the cost to branches based on the number of CBMs ordered by each branch. The remaining cost was not allocated to branches yet; it had been assigned to the group customer instead. For example, in January 2021, the total number of CBMs stored in Speedy's Dammam warehouses was 229. The cost of that capacity was not allocated to Hummy's branch in Dammam directly. Instead, it was allocated to the Hummy group in the first place. Next, the researcher allocated the cost of around 38 CBMs to Hummy's Dammam branch (Branch 1) as this number represented the total CBMs moved out to that branch, and the cost of the remaining 191 CBMs was remained at the group customer level. Tables 69, 70, and 71 in Appendix B present the allocation of Storage activity costs to the seven branches of Hummy. Surprisingly, Branch 1 (located in Dammam City) had the highest records of Storage cost across all three months of Q1-2021 compared to the other branches, where the average cost for that branch was SAR 1,282 compared to SAR 726 as an average cost for all other branches. In Jeddah City, the two branches (Branch 2 and Branch 3) had meagre numbers where the total cost for both branches combined was SAR 2900, less by 32% than Branch 1's total cost (SAR 3,848). In Riyadh City, the four branches had various cost numbers ranging from SAR 1749 to SAR 3554. These numbers reflect each branch's sales and business volume in Q1-2021.

The direct allocation method.

Opposite to the previous method, the direct allocation method was used when there was a direct correlation between activities and branches. The costs of activities such as Processing Orders, Picking & Loading, Invoicing, and Delivery were allocated directly to branches based on different but relevant cost drivers, as Tables 72-74 in Appendix B explain. For example, the costs of the Processing Orders activity were allocated to branches based on the number of sales orders sent by a branch to Speedy. As mentioned earlier, the number of monthly sales orders was almost the same for Dammam and Riyadh branches (ranging from 47-56 per branch/month) and less for the Jeddah branches (16-28 sales orders per branch/month). This resulted in less cost being assigned to Jeddah branches compared to Dammam and Riyadh. Similarly, the cost of Invoicing activity was driven by the number of invoices, which is the same as the number of sales orders. Thus, this activity's cost had the same behaviour found the in the Processing Orders activity.

On the other hand, Picking & Loading and Delivery activities costs were assigned to branches based on the number of cases picked, loaded, and delivered. In some cases, the total number of cases delivered to one branch could be less or more significant than other branches with less or more sales volume. For example, In Feb 2021, Branch 1 had placed 47 orders with a total of 772 cases, while Branch 4 placed 56 orders with 488 cases. The TD-ABC model captured this remarkable variation in the number of cases ordered. Thus, more cost was allocated to Branch 1 than Branch 4. Finally, the assignment of Delivery activity cost was based on the number of cases delivered rather than the distance travelled to each branch. The reason behind this allocation method was the trips' distances were split equally between branches. Trip 2, for example, had two destinations. The truck left the warehouse to deliver the first order to the first destination, and then it went to the second destination before it returned to the warehouse. It is more justified to split the total destination travelled between the two branches than to assign more to one of them as they somehow affect each other.

The unused capacity

According to the general manager, Speedy only hired the SCS to manage the 4PLs activities. In Q1-2021, Hummy was the only customer who dealt with Speedy for the integrated supply chain services, or so-called 4PL services. In other words, the supply chain supervisor, in Q1-2021, was working mainly to serve Hummy. This fact could lead us to conclude that we can measure the cost of unused capacity for the SCS, representing the resource pool HED-SC. Table 77 in Appendix B shows the idle capacity found in the resource pool HED-SC. It can be seen that the idle capacity in HED-SC was significantly high, ranging from 75-78% in Q1-2021. That means the overhead cost assigned to that pool (e.g. SAR 6,477 in Jan 2021) was not efficiently utilised in businesses where only 25% was assigned to the cost objects (SAR 1,619 in January 2021), and the remaining cost was not assigned.

Month	Theoretical capacity (min)	Practical capacity (min)	Productive capacity (min)	Unused capacity (min)	Unused capacity %
Jan	12735	11131	2731.35	8400	75%
Feb	12735	11131	2479.17	8652	78%
Mar	12735	11131	2723.87	8407	76%

Table 6-3: The idle capacity detail for HED-SC resource pools in Q1-2021

The TD-ABC model

The results of the TD-ABC model development through all previous steps can be summarised in Figures 6-14, 6-15, and 6-16 for January, February, and March 2021, respectively.

Step one: **Extract Resources Supplied**

Total GL Expenses
SAR 2,705,217.10

Employees	warehouses	Transportation	Depreciation	Utilities	Maintenance	Insurance	General Expenses
SAR 767,955.29	SAR 802,939.00	SAR485,909.32	SAR 60,891.38	SAR 243,102.26	SAR 77,374.64	SAR 11,783.00	SAR 255,262.21

Step two: **Allocation to resource pools**

All in SAR

DMM-WH-F	**RYD-WH-F**	**JED-WH-F**	**DMM-TR**	**RYD-TR**	**JED-TR**	**HED-AC**
333,646.32	57,634.46	27,013.70	228,789.72	134,376.52	142,315.08	16,888.00
DMM-WH-C	**RYD-WH-C**	**JED-WH-C**	**DMM-LB**	**RYD-LB**	**JED-LB**	**HED-SC**
133,135.30	20,429.50	47,158.07	373,774.40	110,775.35	190,538.12	6,477.00
DMM-WH-A	**RYD-WH-A**	**JED-WH-A**	**DMM-DR**	**RYD-DR**	**JED-DR**	**HED-MG +**
128,027.63	18,665.37	76,903.29	90,972.00	11,321.00	19,759.00	335,632.19
DMM-WH-E	**RYD-WH-E**	**Total allocated to resource pools**				**2,705,217.10**
135,029.48	65,955.58					

Step three: **practical capacity**

Resource	Practical	Capacity unit	Resource	Practical	Capacity
DMM-WH-F	7531.76	CBM	DMM-TR	283200	KM
DMM-WH-C	3288.48	CBM	RYD-TR	254880	KM
DMM-WH-A	2842.08	CBM	JED-TR	160480	KM
DMM-WH-E	6197.52	CBM	DMM-LB	434122	min
RYD-WH-F	1845.12	CBM	RYD-LB	122445	min
RYD-WH-C	638.6	CBM	JED-LB	155839	min
RYD-WH-A	505.92	CBM	DMM-DR	356203	min
RYD-WH-E	2336.16	CBM	RYD-DR	300546	min
JED-WH-F	699.36	CBM	JED-DR	189233	min
JED-WH-C	1661.6	CBM	HED-AC	29130	min
JED-WH-A	2623.84	CBM	HED-SC	11131	min

Step four: **capacity cost rate (CCR)**

Resource	CCR	CCR (SAR)	Resource	CCR (SAR)	Capacity
DMM-WH-F	44.3	1.4	DMM-TR	0.81	KM
DMM-WH-C	40.5	1.3	RYD-TR	0.53	KM
DMM-WH-A	45.0	1.5	JED-TR	0.89	KM
DMM-WH-E	21.8	0.7	DMM-LB	0.86	min
RYD-WH-F	31.2	1.0	RYD-LB	0.90	min
RYD-WH-C	32.0	1.0	JED-LB	1.22	min
RYD-WH-A	36.9	1.2	DMM-DR	0.26	min
RYD-WH-E	28.2	0.9	RYD-DR	0.04	min
JED-WH-F	38.6	1.2	JED-DR	0.10	min
JED-WH-C	28.4	0.9	HED-AC	2.57	min
JED-WH-A	29.3	0.9	HED-SC	0.58	min

Step five: **TD-ABC equations**

TD-ABC Equations

Step six: **allocation to activities**

Step seven: **allocation to cost objects**

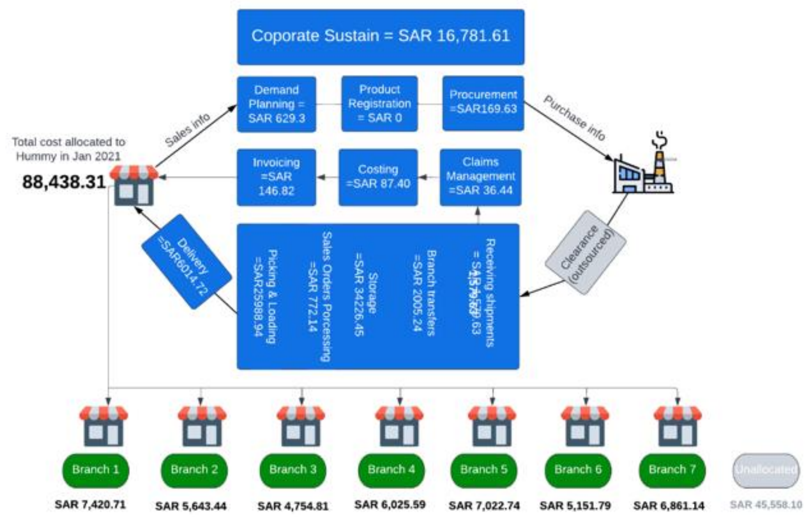

Figure 6-14:The TD-ABC model based on January 2021 results

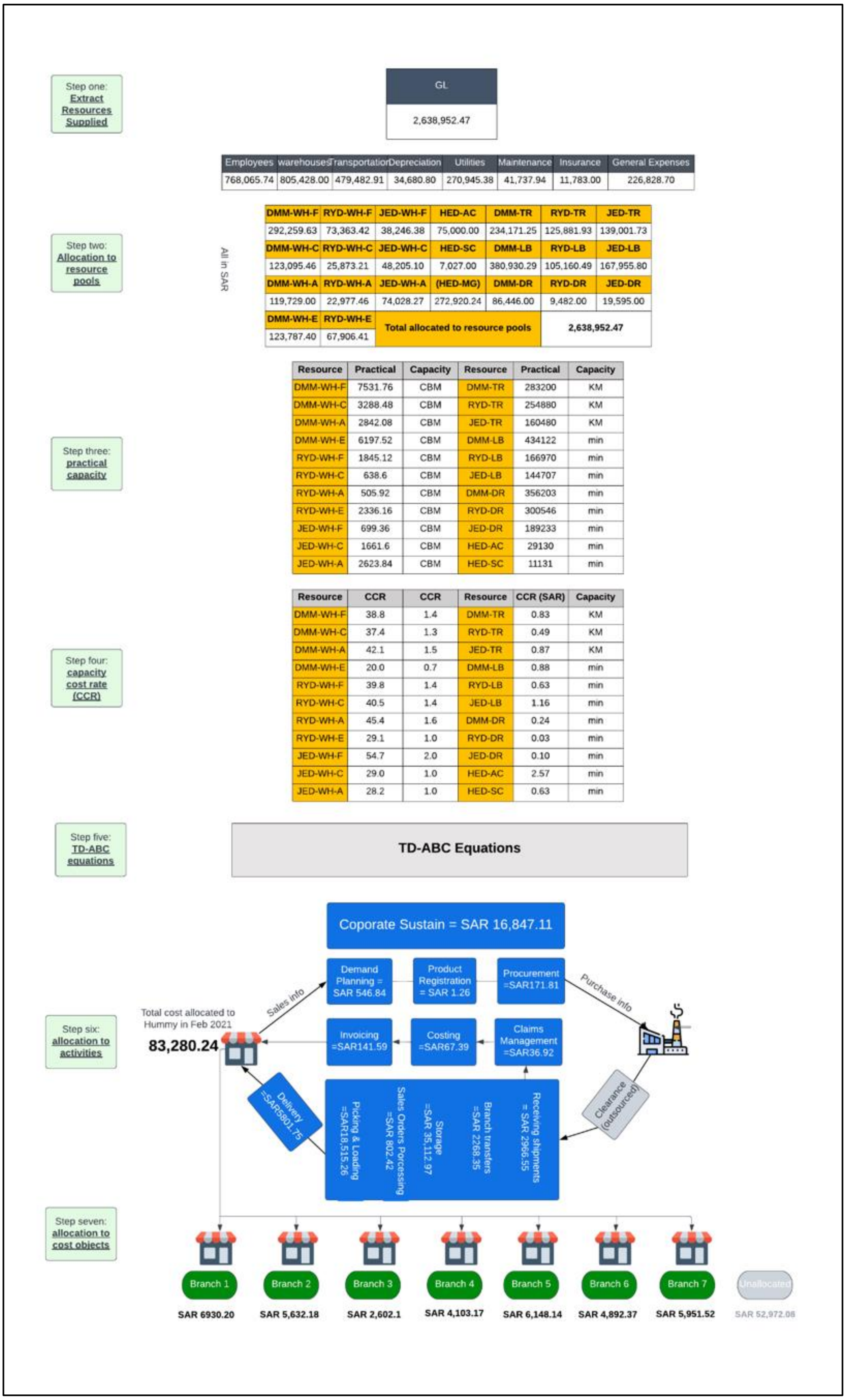

Figure 6-15: The TD-ABC model based on February 2021 results

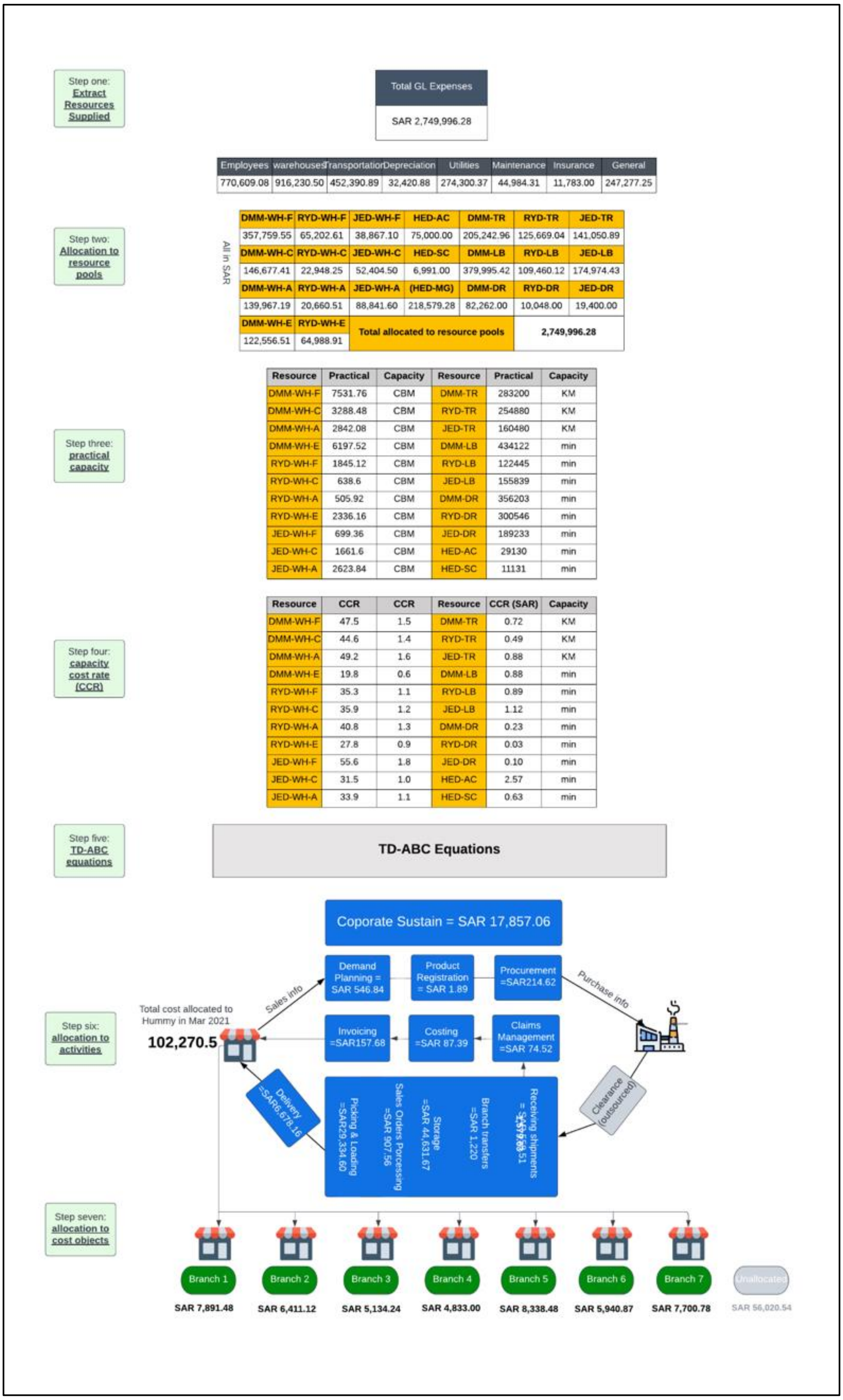

Figure 6-16: The TD-ABC model based on March 2021 results

6.2 Comparison between TD-ABC and ABC model

Developing an ABC model

The second aim of this research is to answer the question: "How will the cost information under the TD-ABC method be different from the cost information generated by the ABC model in the case company?" To answer this question, the researcher developed another costing model for activities in the same period but under the ABC methodology. The sections below explain the steps followed by the researcher and the results per each step.

Step one: GL Data Extraction

This step has no change from the previous TD-ABC model's inputs. The same GL record used in the TD-ABC model development was used again to develop the ABC model. Figure 6-17 shows the GL balance in January, February, and March 2021, as well as the distribution of expenses to the eight main categories.

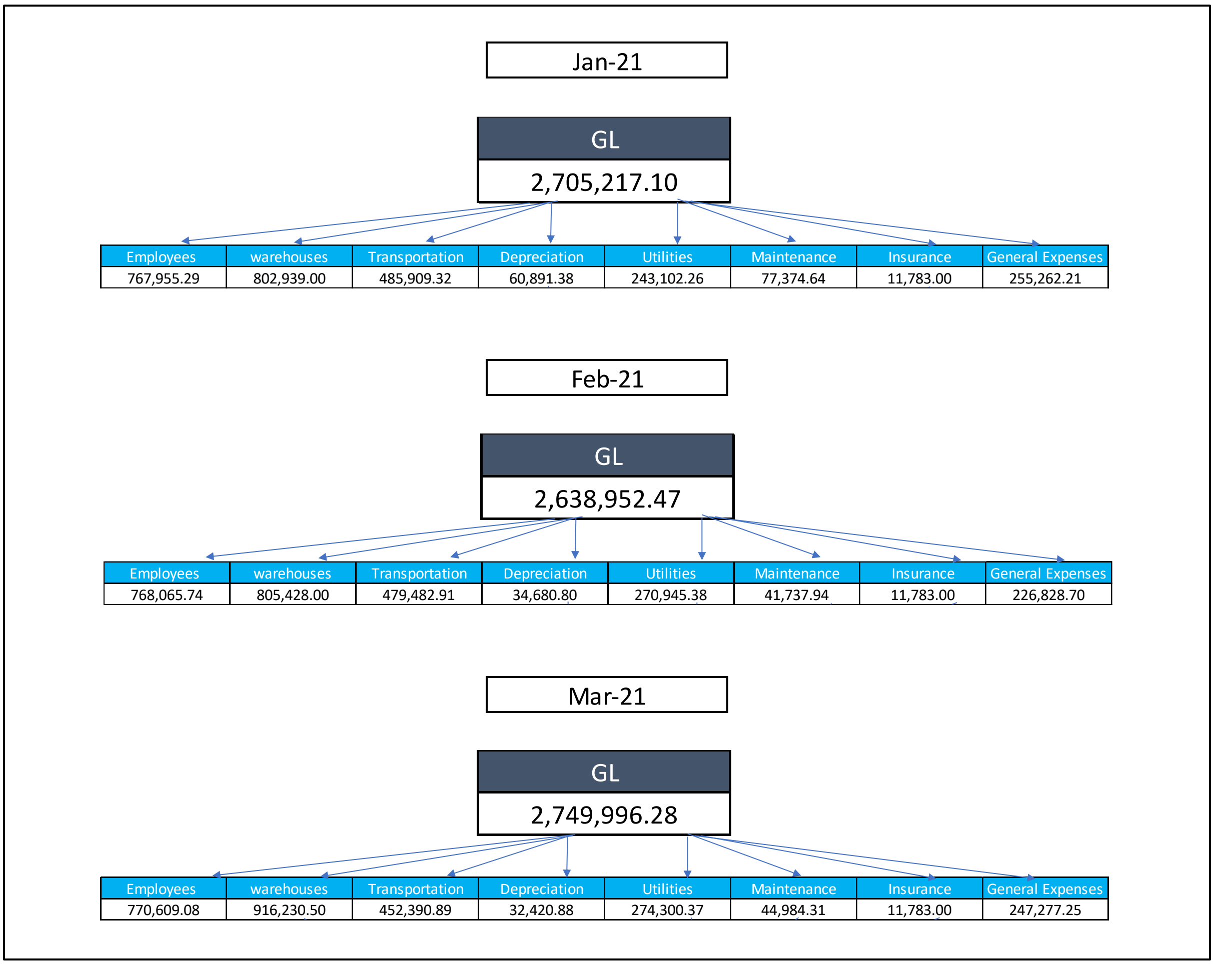

Figure 6-17: The GL expenses allocation in Q1-2021 (ABC model)

Step two: The Assignment of Overhead Expenses to RPs

Similar to the previous step, the TD-ABC and ABC models apply the same mechanism to assign the supplied resource expenses (overhead) to the resource pools. And since the researcher used the same resource pools developed for the TD-ABC model in developing the ABC model, the results, up to this stage, were identical as Figures 1, 2, and 3 in Appendix B show in January, February, and March 2021, respectively.

Step three: The Assignment of RPs Costs to Activities.

As mentioned earlier in Chapter 5, Case-Study Protocol, for comparison purposes, the researcher picked the activities that the HED-SC resource pool was performing and excluded the other activities. The researcher had two options to estimate the time distribution. First, he interviewed the SCS to estimate his time distribution among the five activities, see Table 6-4. Second, the researcher developed another estimate based on the TD-ABC model results, see Table 6-5. The two approaches showed significantly different estimates. Therefore, the researcher relied on the second approach's results, showing more validity and less subjectivity. In addition, he excluded one of the HED-SC activities from this comparison, Product Registration, as it had a trivial impact on the workload in Q1-2021.

HED-SC					
Activity	**Procurement**	**Demand planning**	**Product registration**	**Branch Transfer**	**Orders processing**
Workload	**25%**	**30%**	**5%**	**10%**	**30%**

Table 6-4:HED-SC activities and workload distribution according to the supply chain supervisor

HED-SC						
Activity	**Jan (min)**	**workload**	**Feb (min)**	**workload**	**Mar (min)**	**workload**
Procurement	**175.3**	**6%**	**178.5**	**5%**	**219.3**	**5%**
Demand planning	**1085.0**	**39%**	**868.0**	**23%**	**868.0**	**21%**
Product rego	**0.0**	**0%**	**2.0**	**0%**	**3.0**	**0%**
Branch Transfer	**139.8**	**5%**	**157.0**	**4%**	**193.1**	**5%**
Order processing	**1381.1**	**50%**	**2535.1**	**68%**	**2882.3**	**69%**
Total	**2781.2**	**100%**	**3740.6**	**100%**	**4165.6**	**100%**

Table 6-5: HED-SC activities and workload distribution based on the TD-ABC results

Next, the overhead costs from the HED-SC resource pool were allocated to the four activities based on the workload distribution demonstrated above, see Table 79 in Appendix B. It can be seen that the workload changed from month to month. For example, the Demand Planning activity constituted 39% of the total workload in January 2021 before it dropped to 23% and 21% in February and March, respectively. On the other hand, the Order Processing portion increased from 50% in January to 68% and 69% in February and March, respectively. The other two activities, Procurement and Branch Transfer, remained at 4-6% levels in all three months. According to these percentages, the total overhead cost of the HED-SC was distributed to the four activities. For example, in January 2021, the total overhead cost (SAR 6477) was distributed as follows: SAR 2526.03 to Demand Planning, SAR 388.62 to Procurement, SAR 3238.5 to Order Processing, and SAR 323.85 to Branch Transfer. Next, the cost of each activity was divided by the number of transactions (cost driver) each month. In January 2021, the cost of each Demand Planning transaction was SAR 505.2 as there were five plans in that month (SAR 2526.03/5). Similarly, all other three activities costs were divided in the same way according to the ABC methodology.

Step four: Allocation from activities to cost objects

This is the final stage in the ABC model development, where the researcher divided the allocated overhead cost on the total number of transactions for each activity month by month in Q1-2021. Table 6-6 shows the selected activities, cost objects, cost drivers, and the number of transactions in Q1-2021 month by month per each activity. Next, Tables 75, 76, and 77 in Appendix B present the cost per transaction after allocation.

Resource Pool ID	Activity	Cost object	Cost driver	#. Of transactions		
				Jan	Feb	Mar
HED-SC	Procurement	POs	# Of POs	5	6	7
HED-SC	Demand Planning	Plans	# Of plans	5	4	4
HED-SC	Order Processing	Sales orders	# Of sales orders	336	319	361
HED-SC	Branch Transfers	Transfers	# Of transfers	15	17	21

Table 6-6: Activities, cost objects, cost drivers, and the record of transactions in Q1-2021 for ABC model

The comparison results

The previous four sub-sections helped to calculate the cost per transaction for each activity in the supply chain department HED-SC according to the ABC methodology. This outcome should now be compared with the outcomes of the TD-ABC model that were discovered in the first part of this chapter. Tables 78, 79, and 80 in Appendix B demonstrate how the cost of activities differs between the TD-ABC and ABC models for the selected resource pool. The gap between the two systems' outcomes is remarkable in all three months, where the TD-ABC reports around 75% less cost than the ABC for all activities. For example, the Demand Planning total cost in January 2021 was SAR 2526.03 according to the ABC system while only SAR 629.3 is shown under TD-ABC. The primary reason for this massive gap is that the ABC system allocates the entire department's cost to the four activities, including the cost of idle capacity. In contrast, the TD-ABC system allocates the utilised capacity's cost only, leaving the unused capacity cost unallocated. As mentioned earlier, the supply chain supervisor served only one customer: Hummy. The total time needed to operate this customer's business was around 25% of the supervisor's time. The remaining 75% of his time can be labelled as unproductive time. Accordingly, we can infer that the TD-ABC system captured the cost of this department more accurately than the ABC one.

6.3 The cost and profit reports under the TD-ABC methodology

The existing cost and profit reports

Speedy provided Hummy with a wide range of supply chain services, starting from Demand Planning to Invoicing. The researcher interviewed Speedy's general manager and finance manager to understand how the management used the data provided by its accounting system to analyse its customers' profitability. Interestingly, Speedy didn't use any advanced system or method for cost and profitability analysis. Instead, the managers relied on the customer's P&L statement and the SC method. As the P&L statement in Table 6-7 suggests, the managers can't see the complete picture of the incurred expenses that should be allocated to Hummy. This statement summarised the revenue and expenses incurred in Q1-2021 but did not include the overhead cost such as rent, salaries, and more. Instead, it included revenue and the direct costs caused directly by Hummy. In other words, this statement was not comprehensive; where it shed light on the direct costs only, and it ignored the indirect ones.

	Jan (SAR)	Feb (SAR)	Mar (SAR)	Total (SAR)
SALES	1,131,966	966,173	1,284,145	3,382,284
COST OF SALES	997,777	853,505	1,135,000	2,986,282
GROSS PROFIT	134,189	112,668	149,145	396,002
ENTERTAINMENT	586	0	0	586
TOTAL TRANSPORTATION EXPENSES	39,740	28,626	27,732	96,098
COMPANY GENERAL EXPENSES	7,065	7,615	7,604	22,284
EBITDA	86,798	76,427	113,809	257,706
EBIT	86,798	76,427	113,809	257,706
NET INCOME	86,798	76,427	113,809	277,035
NET INCOME %	7.67%	7.91%	8.86%	8.19%

Table 6-7: Speedy's P&L statement for Hummy's operation in Q1-2021

According to the finance manager, when Speedy needed to go beyond the P&L statement outcomes, it used the SC method with a fixed predetermined overhead cost rate. The aim of using this method was to include all indirect costs in the analysis report. As mentioned in the literature review chapter, this approach relies on one or a few cost drivers to allocate overhead costs directly from resource pools to customers. It does not moderate activities as the ABC and TD-ABC do. Speedy relied on only one cost driver for all resource pools – the number of pallets. Based on that, the company allocated overhead costs to customers by multiplying the number of pallets occupied by a given customer by the predetermined overhead cost rate. According to the finance manager, the overhead cost rate in Q1-2021 was SAR 100 per pallet. Table 6-8 shows the overhead cost allocation to Hummy in Q1-2021 according to this method. The table shows that Hummy utilised 1120, 1070, and 1377 CBMs in January, February, and March 2021, respectively. By converting these CBMs into equivalent pallets (1.24 CBM = 1 pallet), we can infer that Hummy occupied around 903, 862, and 1110 pallets in those three months, respectively. Accordingly, the allocated overhead cost to Hummy was SAR 90,322 in January, SAR 86,290 in February, and SAR 111,048 in March.

Month	# of CBM occupied by Hummy	# of equivalent pallets (cost driver)	Overhead cost rate (SAR)	Allocated cost (SAR)
Jan	1120	903.23	100	90,322.58
Feb	1070	862.90	100	86,290.32
Mar	1377	1110.48	100	111,048.39

Table 6-8: Overhead cost allocation to Hummy in Q1-2021 according to the SC method

The previous table shows how Speedy's management allocated overhead costs to Hummy in Q1-2021. By applying these outcomes to the operational records, we can obtain the net profit from Hummy's business in Q1-2021, as Table 6-9 suggests. Noticeably, the net profit dropped dramatically compared to the P&L statement. For example, the net profit dropped from 7.67% to 3.61% in January, from 7.91% to 2.67% in February, and from 8.86% to 2.56% in March. Furthermore, the behaviour of profitability changed over the three months. For example, according to the P&L statement, March was the best month in terms of profitability, where the net profit was around 8.8% compared to January and February (7.67% and 7.91%, respectively.) However, the profitability of March was the worst, according to the SC approach, where it was 2.56% compared to 3.61% in January and 2.67% in February. The reason behind this shift in the profitability pattern is that the SC method calculated the net profit based on how many pallets were utilised by Hummy in the three months. Since March had the highest number of stored pallets, the cost assigned to March was the highest among all three months. This approach does not reflect the nature of operation at Speedy. Speedy had different activities and services that the number of pallets couldn't measure. Therefore, the following sub-section suggests a new approach for cost and profit reports according to the TD-ABC methodology.

	Jan (SAR)	Feb (SAR)	Mar (SAR)	Total (SAR)
SALES	1,096,518	959,992	1,227,358	3,283,868
COST OF SALES	-966,600	-848,056	-1,084,939	-2,899,595
GROSS PROFIT	129,918	111,936	142,419	384,273

INDIRECT COST	90,323	86,290	111,048	287,661
NET PROFIT	39,595	25,646	31,371	96,612
NET PROFIT % OF SALES	3.61%	2.67%	2.56%	2.94%

Table 6-9: Hummy's profitability in Q1-2021 according to the standard costing model

The cost and profit reports using the TD-ABC methodology

As we have already calculated the cost of supply chain services under the TD-ABC methodology, we can now generate an alternative cost and profitability report using this methodology. Although this methodology is not complying with the General Accounting Accepted Principles (GAAP), it provides valuable insights to the decisionmakers about the customers' consumption behaviour and its impact on profitability. The TD-ABC methodology, as explained earlier, uses more relevant and dynamic cost drivers to allocate overhead costs to customers. Activities' costs were calculated based on the most relevant cost driver that represents the activity's nature. For example, it uses time for Picking and Loading activity, CBM for Storage service, and kilometres for Delivery service. Table 6-10 shows the cost and profit resulting from the activities and services provided to Hummy in Q1-2021 based on the TD-ABC model outcomes.

The report shows how much each activity in the entire operation cycle costs the company. In addition, it shows the proportion that each activity is consuming from revenue. Such details help managers to conduct both vertical and horizontal profitability analyses. To illustrate, managers can compare one activity's cost in a certain period with other periods horizontally. Alternatively, one activity's cost can be compared with other activities' costs in the same period to decide which activity costs more (vertical analysis). For example, Table 6-10 shows that Warehousing cost had the highest portion among all other activities and services (vertical analysis). It also shows that Storage cost in March was the highest among all three months of study (horizontal analysis). In contrast, the Product Registration cost was the lowest among supply chain activities, where it had almost zero in all three months.

Interestingly, the advanced supply chain services such as Demand Planning, Procurement, Branch Transfer, Costing, and Claims Management had significantly lower costs than the popular 3PL services such as Warehousing, Delivery, and Orders Fulfilment. Although these advanced services contributed remarkably to Hummy by ensuring stock availability and smooth operation, the cost of providing such activities is trivial compared to the traditional logistics services' costs. Table 6-11 shows the activities' costs in two different groups, 3PL and 4PL activities. The total cost of 4PL activities consumed only 2% of the gross margin in Q1-2021, while the total cost of the 3PL activities consumed around 56% of the gross margin in the same period.

	Jan (SAR)	Feb (SAR)	Mar (SAR)	Total (SAR)
SALES	1,096,518	959,992	1,227,358	3,283,868
COST OF SALES	-966,600	-848,056	-1,084,939	-2,899,595
GROSS PROFIT	129,918	111,936	142,419	384,273
Operating cost:				
Product registration	0.00	1.26	1.89	3.15
Demand planning	629.30	546.84	546.84	1,722.98
Procurement	169.63	171.81	214.62	556.06
Receiving shipment	1,579.63	2,966.55	558.51	5,104.69
Warehousing	34,226.45	35,112.97	44,631.67	113,971.09
Costing	87.40	67.39	87.40	242.19
Claims management	36.44	36.92	74.52	147.88
Branch Transfer	2,005.24	2,268.35	1,220.00	5,493.59
Order processing	772.14	802.42	907.56	2,482.12
Picking and loading	25,988.94	18,515.26	29,334.60	73,838.80
Delivery	6,014.72	5,801.75	6,678.16	18,494.63
Invoicing	146.82	141.59	157.68	446.09
Total operating cost	71,656.71	66,433.11	84,413.45	222,503.27
Operating cost % of sales	6.5%	6.9%	6.9%	6.8%
Indirect cost	16,781.61	16,847.11	17,857.06	51,485.78
Net profit	41,479.49	28,655.93	40,148.66	110,284.08
Net profit %	3.8%	3.0%	3.3%	3.4%

Table 6-10: Hummy's profitability in Q1-2-2021 according to the TD-ABC model

Furthermore, the TD-ABC model's outcomes can report the cost and profitability on the level of individual branches based on the results of the last step in the development of the TD-ABC model, which is the allocation of overhead costs from activities to cost objects. Table 6-12 summarises Hummy branches' profitability during Q1-2021. The table shows that Speedy’s net profit from servicing Hummy’s branches ranges between 6% and 8.4%. While five branches contributed to Speedy’s profitability by more than 8%, Branch 2 and Branch 3 missed this contribution level and were at the level of 6%. Interestingly, those two branches are located in Jeddah City, while the others are in Dammam or Riyadh cities. This outcome may indicate that the operating cost in Jeddah is higher than in the other locations. For more details on the branches’ profitability, see Tables 81-88 in Appendix B.

		Jan (SAR)	Feb (SAR)	Mar (SAR)	Total (SAR)
	Gross Profit	**129,918**	**111,936**	**142,419**	**384,273**
4PL services	Product registration	0.00	1.26	1.89	3
	Demand planning	629.30	546.84	546.84	1,723
	Procurement	169.63	171.81	214.62	556
	Costing	87.40	67.39	87.40	242
	Claims management	36.44	36.92	74.52	148
	Branch transfer	2,005.24	2,268.35	1,220.00	5,494
	Invoicing	146.82	141.59	157.68	446
	Total cost	3,074.83	3,234.16	2,302.95	8,612
	% of gross profit	**2%**	**3%**	**2%**	**2%**
3PL services	Receiving shipment	1,579.63	2,966.55	558.51	5,105
	Order processing	772.14	802.42	907.56	2,482
	Warehousing	34,226.45	35,112.97	44,631.67	113,971
	Picking and loading	25,988.94	18,515.26	29,334.60	73,839
	Delivery	6,014.72	5,801.75	6,678.16	18,495
	Total cost	68,581.88	63,198.95	82,110.50	213,891
	% of gross profit	**53%**	**56%**	**58%**	**56%**

Table 6-11: Cost and profitability distribution between 3PL and 4PL activities

A question can be raised about the difference between the net profit numbers reported in the branches' profitability summary and those shown earlier in Table 6-12. The gap between those two sources is represented in the profitability of the group customer. As mentioned earlier, Hummy operates seven branches in Saudi Arabia. However, not all logistics costs were passed down to those branches. Some costs remained unallocated. Instead, they were assigned to Hummy as a whole entity. Those costs were the cost of Storage and the corporate-sustain cost. The TD-ABC model suggests allocating overhead cost according to the consumption volume. Thus, as there was no consumption from branches to the resources that caused these excessive costs, the researcher paused the flow of these costs at the level of the group customer rather than passing them down to branches. Table 6-13 shows the costs allocated to Hummy as a group customer.

	Branch#1	Branch#2	Branch#3	Branch#4	Branch#5	Branch#6	Branch#7
SALES	641,911.00	324,253.05	230,482.33	409,850.50	614,335.50	455,164.83	601,820.67
COST OF SALES	-567,485.88	-287,086.24	-203,916.50	-361,511.96	-541,817.03	-401,527.70	-530,918.32
GROSS PROFIT	74,425.12	37,166.81	26,565.83	48,338.54	72,518.47	53,637.13	70,902.35
Operating cost:							
Demand Planning	284.31	130.10	102.89	301.21	302.59	297.30	304.54
Procurement	84.27	38.73	30.30	89.75	90.19	88.61	90.89
Receiving shipments	817.84	378.00	286.64	905.57	899.22	883.14	929.38
Costing	40.62	17.40	14.28	42.41	42.36	41.54	42.63
Claims management	24.39	11.36	8.89	25.68	25.99	25.54	25.92
Branch transfer	896.57	409.97	318.97	965.94	965.65	948.59	981.66
Delivery	2,381.11	5,037.41	3,429.29	1,533.24	2,261.68	1,665.77	2,161.65
Order processing	408.35	188.37	146.91	434.26	436.71	428.59	438.92
Invoicing	73.36	33.72	26.88	77.92	78.37	77.01	78.84
Picking and loading	13,381.78	9,757.56	6,906.47	8,835.75	12,851.87	9,595.74	12,509.62
Warehousing	3,849.89	1,683.02	1,219.27	1,749.68	3,554.05	1,932.44	2,948.87
Total operating cost	22,242.48	17,685.62	12,490.80	14,961.41	21,508.68	15,984.27	20,512.92
Net profit	52,182.64	19,481.19	14,075.03	33,377.13	51,009.79	37,652.86	50,389.43
Net profit %	8.1%	6.0%	6.1%	8.1%	8.3%	8.3%	8.4%

Table 6-12: Hummy's branches profitability summary in Q1-2021

Group				
	Jan (SAR)	**Feb (SAR)**	**Mar (SAR)**	**Total (SAR)**
SALES	0.00	0.00	0.00	0.00
COST OF SALES	0.00	0.00	0.00	0.00
GROSS PROFIT	0.00	0.00	0.00	0.00
Operating cost:				
Demand planning cost	0.00	0.00	0.00	0.00
Prodcurement cost	0.00	0.00	0.00	0.00
Receiving shipment cost	0.00	0.00	0.00	0.00
Warehousing cost	28,740.91	30,173.19	38,119.78	97,033.88
Costing cost	0.00	0.00	0.00	0.00
Claims management cost	0.00	0.00	0.00	0.00
Branch transfer cost	0.00	0.00	0.00	0.00
Order processing cost	0.00	0.00	0.00	0.00
Picking and loading cost	0.00	0.00	0.00	0.00
Delivery cost	0.00	0.00	0.00	0.00
Invoicing cost	0.00	0.00	0.00	0.00
Total operating cost	28,740.91	30,173.19	38,119.78	97,033.88
Operating cost % of sales	-	-	-	-
Indirect cost	16,781.61	16,847.11	17,857.06	51,485.78
Net profit	-45,522.52	-47,020.30	-55,976.84	-148,519.66
Net profit %		-	-	-

Table 6-13: Overhead costs assigned to Hummy as a group company in Q1-2021

Conclusion:

This chapter sheds light on the role of the TD-ABC model in integrated supply chain management. The researcher developed a TD-ABC model that showed the sophisticated capability to capture the cost of the integrated supply chain services in the case company Speedy. Even though the development of the TD-ABC model requires significant effort and a long process starting from the analysis of the company's GL, observing the supply chain activities, building resource pools, developing time equations, and allocating the cost according to the equations' outcomes, this effort pays off as it results in more detailed and relevant numbers per each activity. The researcher then compared those numbers with the cost numbers generated using a different technique, the ABC method. The comparison result was interesting as the gap between the two methods was huge. The researcher will discuss this gap in more detail in the next chapter. Finally, the researcher investigated the role of the TD-ABC model in generating more transparent and insightful reports for the cost and profit in the case company, developing customer profitability reports on the level of the case customer (Hummy) entirely and on the level of each individual branch. Although the reports didn't show a significant difference in the overall bottom line compared with the existing reports generated by Speedy's finance team, the elements of the customer profitability report generated by the TD-ABC model are more detailed; thus, it could be decisive for the decisionmakers in the company.

Chapter 7 : Discussion

Introduction

In the previous chapter, the researcher presented analysis results that explain the role of the TD-ABC model in integrated supply chain services. This chapter is dedicated to discussing the analysis outcomes and finding out how they could be linked to the literature. This chapter is divided into five sections. Section 7.1 discusses the process of the TD-ABC model development. Section 7.2 discusses the comparison between the TD-ABC and ABC models, and Section 7.3 dives more profoundly into the cost and profit reports quality and sheds light on the results of the comparison between the P&L, SC, and the TD-ABC approaches when it comes to the profitability reports. This discussion is beneficial to give the reader more insights into how different systems can lead to different conclusions. Section 7.4 focuses on the improvement opportunities for the integrated supply chain services when implementing the TD-ABC model. The Section 5 is Conclusions.

7.1 The Process of Developing a TD-ABC model

Step one: The GL Data Extraction

The researcher extracted the GL data from Speedy's financial accounting system to examine the resources supplied to the different departments in Q1-2021. This step is crucial in the model development process as the researchers must be careful when considering data that should be included in the costing model development. Unfortunately, most of the previous studies that discuss TD-ABC development, such as (Afonso & Santana, 2016; Everaert et al., 2008; Ma, 2014) did not elaborate on this step, and they skip directly to the time equations and results. Although their research aims justify this, the researcher finds it advantageous to present how the financial accounting system could affect the quality of the activity-based costing models. Bragg (2013, p. 337) argues that the best practice in financial accounting makes implementing the ABC system more manageable and reliable. He, in addition, claims that the right categorisation and sound code structure for GL accounting leads ultimately to sound management decisions. This argument is valid when it comes to implementing the TD-ABC system since both ABC and TD-ABC systems share the same method of development in some stages, including allocating resource expenses to departments or resource pools.

Step two: The Assignment of Overhead Expenses to RPs

Defining resource pools was one of the exciting challenges faced in this research. This step required a deep understanding of the case company's operation cycles and the organisational chart. Although some may use the company's existing departments or cost centres as resource pools as reported in (Ma, 2014), this could be misleading if the department or cost centre reports variations in the resource types it consumes. At Speedy, for example, the researcher found this scenario familiar. Warehouses were considered as one cost centre whereas they should be disaggregated into multiple ones. The Dammam internal warehouse can be seen at the first glance as a single warehouse (one cost centre), in which case it should have one capacity cost rate for the TD-ABC model. Investigating the resources that this warehouse consumed and the activities it performed revealed that different sections inside this warehouse which consumed different types of resources to provide different services. Based on this finding, the researcher expanded the number of resource pools to reflect this differentiation and to ensure more accurate outcomes.

The method of defining resource pools used in this research aligns with the findings reported by (Balakrishnan et al., 2011) who found that cost systems gain more accuracy with the increase of the resource pools number especially when those pools were disaggregated based on their correlation with the resource consumption patterns. (Lueg & Morratz, 2017; Wu et al., 2011) state that aggregation of resource pools is a common error in TD-ABC development, and it leads to less accuracy in the outcomes. Therefore, when developing a TD-ABC model, especially for diverse resource-patterns-based businesses, the cost system designers should be careful to avoid this error. “When a firm’s costing system does not reflect resource consumption patterns with sufficient accuracy, managerial decisions may result in wrong pricing policies, wrong product planning and ultimately in sub-optimal profits.” (Labro & Vanhoucke, 2008, p. 1715).

Step three: The Practical Capacity

Kaplan and Anderson (2004) suggest that the practical capacity can be measured randomly by assuming 80-85% of the theoretical capacity. They encourage researchers and practitioners not to exaggerate in seeking the precision of the model. “It’s important not to be overly sensitive to small errors. The objective is to be approximately right, say within 5% to 10% of the actual number, rather than precise” (Kaplan & Anderson, 2004). “An error of a few percentage points will rarely be fatal” (Anderson & Kaplan, 2007, p. 20). However, if the researcher decided to use this arbitrary way to calculate the practical capacity in this research, and randomly used 80% as a practical capacity percentage, the capacity cost rate per each resource pool would drop by 7%; thus, the cost of each activity in those pools will follow and drop at the same level, which ultimately could affect the bottom line. That doesn’t mean that the mathematical approach is 100% precise, but it was more justified and supported by facts and numbers collected from the company’s system. Therefore, this research disagrees with using the random assumption for the practical capacity calculation suggested by (Anderson & Kaplan, 2007).

The previous researchers followed different ways to obtain or compute the practical capacity. Some researchers, such as (Everaert et al., 2008; Somapa et al., 2012) embraced the notion of random assumption. Their case study-based research assumed that the practical capacity could be calculated at 80%. Afonso and Santana (2016) used the efficiency rate found in the case company's ERP system, which was 77.5%. Au and Rudmik (2013) calculated the actual practical capacity of full-time nurses in an outpatient clinic by collecting data about work hours, days, breaks, holidays, and sick days. They assumed this number should be applied to other groups, such as admin. employees and capital equipment.

On the other hand, Ma (2014) calculated the practical capacity rate using the same mathematical approach used by (Au & Rudmik, 2013). However, the two studies differ in using single or multiple rates for different resource pools. While (Au & Rudmik, 2013) applied a single practical capacity rate for all business units, Ma (2014) agrees with this thesis that the practical capacity rate should vary if the working hours differ from one department to another. For example, Ma (2014) investigated the capacity of five departments and found three practical capacity rates ranging from 65% to 80%. This thesis showed a difference between the practical capacity in the operation floor and offices. That difference affected the capacity cost rates. Such findings emphasise the superiority of the mathematical approach over the random way when calculating the practical capacity rate.

Somapa et al. (2012) state that assessing the practical capacity is difficult, especially in small and medium-sized businesses. Irregular working hours with the absence of advanced systems that track employee status and time make it almost impossible to compute the rate accurately. Namazi (2016) agrees with this aspect of complexity in the TD-ABC model, and he believes this is an obstacle that flaws the model's simplicity. This research reveals that these objections are, to some extent, valid. The number of workers, especially in the logistics industry, fluctuates with the current operational levels. From the record of employment collected from Speedy's HR department, the researcher found that the number of workers who worked in warehouses during Q1-2021 was not stable. This could be attributed to the notion that some workers were rented from a third-party recruitment company to meet demands on logistics services, and they were on month-to-month contracts. This leads us to conclude that practical capacity determination is not an easy step in the process of the TD-ABC model. Companies need to use advanced HR systems that can trace employment status accurately. The TD-ABC model can be fed with the necessary data to calculate the practical capacity by such advanced HR systems.

Step four: Defining Activities and Times

The researcher observed the operation process at Speedy for three months to understand the activities and time needed in each part of the integrated supply chain services. This task was difficult as it required repetitions to capture the proper sequence of steps and times. Although (Anderson & Kaplan, 2007) state that interviewing managers and workers to understand activities and to estimate times is a proper way when developing a TD-ABC model, the researcher has a different point of view based on the experience in this research. The researcher initially interviewed the departmental managers to understand the departmental activities and resources. Next, he moved to the shop floor to observe activities in more depth. The researcher found, in some cases, different scenarios from what he collected in the interviews. Managers often have a general understanding of the tasks people do on the ground, but they might be unaware of the details of those tasks. In addition, daily events may force workers to modify the actual process in a way that works more effectively. Such updated and detailed steps might be absent from researchers or practitioners who rely on interviews only in developing any costing model. This issue was also reported in (Lueg & Morratz, 2017), where the researchers found discrepancies between the results of interviews and the ERP data. Therefore, it’s recommended to use interview outcomes to enlighten the system designers about the process in general but not to use as a primary data source for TD-ABC development.

The TD-ABC model’s advancement cannot be utilised efficiently without other advanced technologies. The researcher found that some activities were not recorded in the company’s ERP system; thus, it formed an obstacle when adopting the TD-ABC methodology. For example, Speedy did not use the WMS when managing Hummy’s inventory. This prevented the researcher from using the WMS advanced reports to calculate the storage cost based on the actual holding days per item. The researcher, instead, used the average holding days per SKU to calculate the approximate cost of storage services. Another evidence of the WMS necessity for the TD-ABC application was seen in the Picking & Loading activity. Without the WMS, workers used their experience and memory to navigate inside warehouses to pick items. What if a new worker joined the team? The time he will need to pick the same items will be significantly different, while the TD-ABC model will calculate this activity's cost based on the standard times set previously.

Furthermore, what if the locations of SKUs changed? This scenario happened and was observed by the researcher, and it usually happened when new shipments arrived. If the company used the WMS integrated with the TD-ABC system, the relocation behaviour will not cause any issues with the validity of TD-ABC formulas. Once workers update the SKU’s location using the WMS handheld devices, the TD-ABC system can capture the new location and update the cost accordingly.

Bahr and Price (2016) technically proved this advantage in the TD-ABC model by integrating the TD-ABC system with the RFID technology in a warehouse that used the WMS. The researcher found that the TD-ABC could dynamically and automatically calculate the cost of picking based on the SKU's location. The TD-ABC model in that study reported a drop in the cost of picking by 30% when the locations of SKUs were defined and updated in the WMS using the RFID chips. Even though this reduction was not attributed directly to the adoption of TD-ABC itself but to the increase in operation efficiency, the TD-ABC was the mirror that reflected the results of that efficiency on the cost of operation.

Defining activities and times to develop a TD-ABC model in the supply chain department was harder than it was in the warehouses and the transportation department. Estimating times for activities that demanded communication and planning was more challenging than routine-based activities such as Processing Orders and Picking & Loading. This difficulty in the TD-ABC development was also stated in (Cheporov & Cheporova, 2014) who argue that the TD-ABC methodology is unsuitable for "forethought and creative thinking" activities. The Demand Planning activity, for example, required a comprehensive review of the sales performance and quantity on hand per SKU during the past periods, as well as required projection for future events that may affect sales positively or negatively. In addition, the SCS at Speedy needed to discuss his plans with the customer's supply chain team weekly. Such tasks had, surely, variant durations based on many factors that could not be predictable and thus defined easily in the TD-ABC model.

Lueg and Morratz (2017) identified eight potential errors that may occur throughout the TD-ABC model development, including selecting activities. The authors reported that selecting activities is not a straightforward step, especially for those activities that have cross-pattern concern. Their study found that in the testing activity, for example, in their manufacturing case company, was performed across multiple workshops or resource pools. Consequently, researchers claim that tracing the entire activity steps across multiple stations complicates the model development. In addition, such overlap between resource pools may increase the probability of aggregation errors, according to the researchers. This finding aligns with what was seen in the case of the Branch Transfer activity in this research. This activity spanned multiple pools, starting from the supply chain department, sending warehouse, and transportation, ending at the receiving warehouse. Each pool performed a part of the entire process and had dynamic expense and capacity patterns. Such a changing environment made the mission harder for the cost system designer to define the activity's start and end points compared to other activities that have shorter spans.

Step five: Calculating the CCRs

This step is straightforward. The CCRs are the product of the total supplied expenses (Step one) divided by the practical capacity (Step three).

Step six: The Time Equations

Anderson and Kaplan (2007) attribute the distinction of the TD-ABC methodology over the traditional ABC system to the notion of time equations. Compared to the ABC model, the TD-ABC model can incorporate more variables and characteristics of processes with fewer cost drivers. This feature was confirmed in this research when the researcher examined the capability of the TD-ABC equations to capture the complexity of the operation processes along the integrated supply chain. As this research findings show, some activities, such as Procurement, had many variations that affect the activity's performance time and, thus, cost. In the Procurement activity example, there were around 18 steps and nine crossroads along the process map. Thus, there were around 162 probabilities of performing this activity depending on many factors related to the suppliers and products. However, the TD-ABC model succeeded in incorporating all these variations in two short equations, whereas in the case of the traditional costing systems, ABC, for example, the cost estimation for this activity would need tens of cost drivers to capture the same level of complexity. This finding supports the idea that the TD-ABC model is simpler and more flexible for updates and upgrades than the traditional ABC system, as discussed in the following sections.

Step seven: Allocation to Cost Objects

Anderson and Kaplan (2007) state that the TD-ABC model's superiority over the traditional costing models, including ABC, is attributed to the capability of driving the actual cost down to deeper levels beyond the customer or supplier level. It can, in other words, capture the variations in specific products or orders and assign the right amount of cost to customers accordingly. Whereas, in the traditional costing methods, the allocation of overhead costs to a specific customer is based on the number of transactions related to that customer regardless of the variability in the resource consumption between transactions. The result of this research, especially in this stage of model development, confirmed this superiority in the TD-ABC model. Although the research scope was limited to one case customer, the model enabled the researcher to dive deeper into the level of branches of that customer. The TD-ABC model successfully allocated overhead costs from activities to branches based on the number of resources consumed by each branch. That consumption was calculated by the time equations developed in the previous step, considering the type of activities and the number of resources provided to each branch.

Another reported characteristic in the TD-ABC methodology is the identification of idle capacity cost. This cost results from the difference between the total overhead cost in a specific resource pool and the allocated cost to cost objects. In other words, it's the remaining part of the overhead after allocating overhead costs from resource pools to the cost objects. The previous researchers consider this as another advantage of the TD-ABC methodology, and they calculated the cost of idle capacity for the resource pools investigated within their research scope (Afonso & Santana, 2016; Dalci et al., 2010; Järvinen & Väätäjä, 2018; Ma, 2014). This research reported less utilisation of this advantage in the TD-ABC methodology. The researcher could not calculate the idle capacity for most of the resource pools. This limitation is attributed to the fact that this study's scope is limited to one case customer within one logistics company. The unused capacity calculated after the overhead allocation from resource pools to the cost objects can't be considered idle capacity only. Instead, it combines both capacities allocated to other customers (other un-investigated cost objects) and idle capacity. Consequently, the only resource pool eligible for such investigation was the supply chain department HED-SC as it was operating to serve one customer only, Hummy.

The calculation of unused capacity in the HED-SC resource pool showed a big waste of the pool's resources. As presented in the findings chapter, the utilised capacity represented 22-25% of the practical capacity in that pool. In a similar study conducted by (Zhang & Yi, 2008), the researchers found that the utilisation capacity for logistics activities ranged between 67-81%. Afonso and Santana (2016) reported higher utilisation rates where the productive capacity represented 71-85% of the total practical capacity in three resource pools. The inefficient utilisation of the practical capacity in the HED-SC could be attributed to the low workload assigned to the SCS. In Q1-2021, the SCS served only one customer with stable operational requirements. Another probability that may justify this low utilisation was that some supply chain activities were performed out of the system; thus, they were not traceable accurately, or they were excluded entirely from the model. For example, communication was a time-consuming activity in that the SCS was involved. However, there was no way to easily track and record the number and times of communications. That does not mean that if we succeed in considering these activities, we will get a regular utilisation rate, but we will, at least, observe a higher rate than the calculated one. Both assumptions, the low workload and the difficulty of tracking some activities, significantly broadened the gap between the practical and productive capacity in the supply chain department.

7.2 The comparison between TD-ABC and ABC

One of the aims of this research is to compare the TD-ABC with the ABC methodologies when allocating overhead expenses to the supply chain services. This research revealed massive differences between calculations of the two systems. In this section, the researcher discusses the rationales behind these discrepancies between the TD-ABC and ABC calculations.

First of all, the two models use two different strategies when allocating overhead costs to the cost objects. While the ABC model is a push system that allocates the total overhead cost of the resource pools to the cost objects, the TD-ABC methodology is a pull system allocating a part of the total overhead cost to the cost objects based on the volume of consumption (Namazi, 2016). The gap between the outcomes of the two methods is expressed in the cost of unused capacity. This difference between the two strategies can justify the discrepancies reported in this research for the cost of supply chain services between the TD-ABC and ABC models. For example, the overhead expenses assigned to the resource pool HED-SC in both ABC and TD-ABC models were identical (e.g. SAR 6477 in January 2021). However, the ABC model allocated the total cost to the cost object, Hummy, while the TD-ABC model allocated only SAR 1670 to the same object. This partial allocation by the TD-ABC model represents around 26% of the total overhead expenses in the designated resource pool, which is equal to the percentage of the utilised capacity in that resource pool, (Figure 7-1). This aspect of comparison between the two systems shows the TD-ABC methodology as a superior tool for accurately costing and evaluating the departments' capacity utilisation.

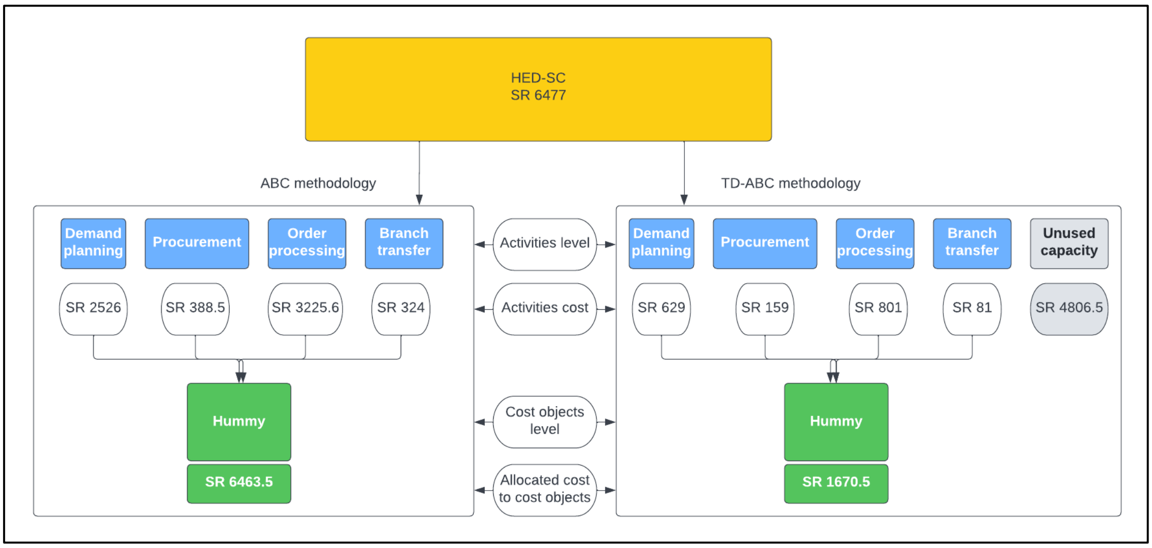

Figure 7-1: The difference between the allocation results in TD-ABC and ABC models

As discussed previously, the HED-SC resource pool was responsible for managing the 4PLs services such as Demand Planning, Procurement, and Processing Orders. In Q1-2021, Speedy had only one SCS who managed only one 4PL customer (Hummy). Considering the fact that this supervisor was purposely hired to manage Hummy's activities, someone may raise a valid question that is should we allocate 100% of this department's expenses to the customer who caused them? In other words, can we consider the ABC allocation a valid method in such cases where we can allocate 100% of the overhead expenses to a single cost object? As seen in this research results, the TD-ABC model allocated the utilised capacity cost to Hummy, leaving the remaining cost unallocated. In comparison, the ABC model allocated the entire resource pool costs to Hummy, including the cost of unassigned capacity. Anderson and Kaplan (2007), in their TD-ABC guiding book, address this controversial point and suggest:

"If the capacity were acquired to meet anticipated demands from a particular customer or a particular market segment, then the costs of unused capacity due to lower-than-expected demands can be assigned to the person or organisational unit responsible for that customer or segment."(Anderson & Kaplan, 2007, p. 55).

(Anderson & Kaplan, 2007) suggestion above leaves Speedy's management with three assignment options: to follow the ABC method that assigns 100% of costs to Hummy without distinguishing between the utilised capacity and the idle capacity costs, to use the TD-ABC partial allocation where the unused capacity cost remains unassigned to any cost object, or to follow the TD-ABC method with 100% assignment to Hummy including the unused capacity cost, (Figure 7-2). Companies have different preferences regarding including or excluding the unused capacity cost (L Zimmerman, 2011).

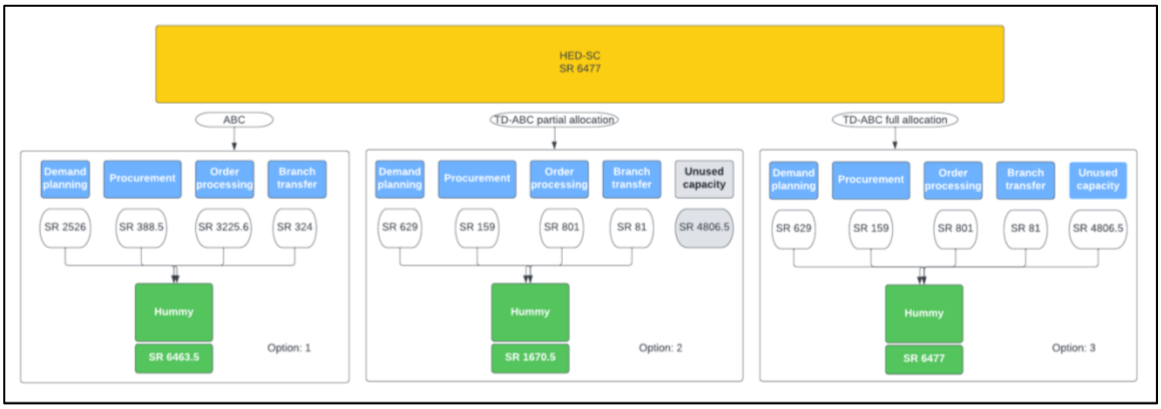

Figure 7-2: The three allocation options for (HED-SC) costs

Anderson and Kaplan (2007) state that one of the significant differences between the TD-ABC and ABC systems is that the TD-ABC system expands linearly while the ABC system expands exponentially. That makes the former more manageable and flexible in the case of system updates and maintenance. In a similar study to this thesis, Anderson and Kaplan (2007) refer to a logistics company that decided to replace the ABC system with a TD-ABC one. As a result of that decision, the model's size dropped from 900 activities to 100. In another case, the system's size shrinked from a 250-terabyte model to only 25 terabytes when a retailing company upgraded its cost model from ABC to the TD-ABC (Anderson & Kaplan, 2007). The investigation of this study reveals the same issue in the ABC model design. The Claims Management activity required evaluating the damaged item's value. If it's above a certain level, the company could claim this incident to the insurance company. Otherwise, there was another process to close the incident report internally. The ABC model deals with these two scenarios as two separate activities with different cost drivers. On the other hand, the TD-ABC considers this as one activity as it can inherit the two scenarios in one equation. This outcome agrees with (Everaert et al., 2008) finding that the ABC cost information is too aggregated; thus, not helpful to management unless we multiply the number of activities and cost drivers. By expanding this example to the rest of the supply chain activities, one can infer that the ABC model is unsuitable for such complex settings and it's more subject to abandons by users.

However, this study suggests that even though the maintenance and updates for the ABC system are complicated tasks, the development process for the ABC system is easier for the designers than the TD-ABC one. An important observation when developing the two models in the same settings is that the TD-ABC model required more data and effort from the researcher than the ABC model. The TD-ABC model development required the researcher to dive deep into the processes and activities to collect data about steps, times, distances, spaces, practical capacity, and more. To collect such a vast amount of data, the researcher needed several means, including observations, to ensure that data represent the standards and average of the operations in the case company. Otherwise, the TD-ABC system will not be able to generate accurate outcomes. On the other hand, the ABC system primarily relies on the system user's contribution. The researcher needed the employee's judgement about activities and workload distribution in each department. The researcher didn't need time and steps data for the ABC development, saving time and effort. However, for research purposes, he used the time data he had already collected to develop the TD-ABC model to validate the employees' judgement on workload distribution.

The use of time data to validate the participants judgement revealed and confirmed one of the most common shortcomings in the ABC methodology, which is the subjectivity of interviewees when collecting data (Anderson & Kaplan, 2007). The ABC model relies on the employees' estimates of the workload distribution and time spent performing activities (Cooper & Kaplan, 1992). However, these estimates are subject to errors (Datar & Gupta, 1994). In this research, the researcher clearly found this disadvantage in the ABC design. The discrepancy between the workload distribution suggested by the SCS and the one developed by the researcher indicated this issue. The supervisor reported the following distribution: Demand Planning 30%, Procurement 25%, Processing Orders

30%, Branch Transfer 10%, and Product Registration 5%. On the other hand, the researcher developed another distribution scheme based on the observation findings used for the TD-ABC model. He found the following results (on average): Demand Planning 28%, Procurement 5%, Processing Orders 62%, Branch Transfer 5%. The latter approach, theoretically, should provide more precise estimates as it resulted from several observations and traceable records. Therefore, this research confirms that the data collection in the ABC design is subject to errors, as suggested by (Datar & Gupta, 1994).

Finally, incorporating time equations in the TD-ABC system allows for more benefits that certainly make it superior to the ABC system. For example, time equations serve as a critical element in capturing the complexity of various business processes. These equations provide a comprehensive understanding of how time is allocated across different activities, thereby offering a more accurate representation of operational complexity (Anderson & Kaplan, 2007). Management can take initiatives to continuously improve these processes based on the TD-ABC outcomes. Moreover, the time equations not only facilitate a detailed cost analysis but also enable dynamic simulation models that can predict the financial impact of changes in activity times or resource costs (Demeere et al., 2009). Furthermore, they serve as a foundational tool in the design of cost reduction plans by identifying inefficiencies and areas for improvement (Everaert et al., 2008). In essence, time equations in TD-ABC act as a multifaceted instrument for operational analysis, cost optimisation, and strategic planning.

In short, the comparison between the ABC and TD-ABC models shows a vast discrepancy in the amount of overhead costs allocated to the cost objects. This discrepancy was attributed to the allocation method that each model follows. While the TD-ABC disaggregates the cost of utilised capacity from the unused capacity costs, the ABC model allocates the total overhead costs to the cost objects. This research also reveals that even though it is argued that the TD-ABC system is easier to maintain and update compared to the ABC system, the development process for the TD-ABC model requires more data and effort from the cost model developer than the ABC model does. The latter relies more on the employee experience and does not require the system designers to dive profoundly into the steps and times of activities. However, this employee participation could lead to a significant issue: the overestimation of workload distribution. This issue will, ultimately, cause inaccuracy in the system's outcomes. Last but not least, the TD-ABC system provides more strategic perspectives than the ABC system due to the mechanism of time equations. These equations not only determine the unused capacity in the company's departments but also help in resource allocation, cost reduction plans, process optimisation, and more.

7.3 The quality of TD-ABC Cost and Profit Reports

This research aims to discover how the TD-ABC methodology can generate informative cost and profit reports. To measure this aim, a comparison between the TD-ABC's reports and Speedy's existing reports was demonstrated. The previous chapter shows the breakdown of serving costs per each Hummy's branch in Q1-2021 and the profitability reports based on the TD-ABC model, the profit and loss statement, and the standard costing model. The TD-ABC model has successfully generated rich insights not only on the customer's level but also on the services level. The time equations that the TD-ABC methodology incorporates captured the details of each branch's orders in the selected period. The type of products ordered, size of cases, number of pallets, and more variables were considered in the cost calculation. In addition, the equations could calculate the cost per delivery based on the branches' destinations. Such details allowed TD-ABC to calculate the cost-to-serve per branch more efficiently than the profit and loss statement and the standard costing model.

Kaplan and Anderson (2004) state that TD-ABC is a powerful tool for conducting CPA. This type of analysis is crucial for any line of business and gets more critical in service-based ones. "For service companies, customer profitability is far more important than product profitability." (Anderson & Kaplan, 2007, p. 201). The authors justify this notion by claiming that the customer's behaviour could significantly affect profitability. The findings of this research support this notion. Even though the seven branches of Hummy operate in the same way, receive the same services from Speedy, and place orders for the same products at the same direct cost rates, the percentage of net profit generated from those branches differs from one branch to another. The behaviour of branches when placing orders and distance from Speedy's DCs resulted in variable profit margins. This was clear in the example of Branches 2 and 6, where one placed fewer orders but received more cost assignments than the other. In addition, TD-ABC discovered that branches in Jeddah City (Branch 2 and Branch 3) had the lowest net profit rates compared to the branches in Riyadh and Dammam. This finding could help managers to investigate the real causes of the high operational cost in Jeddah.

The fact that this study investigates the cost to serve seven branches that operate under one company's name made the results look different from what was reported in previous studies. While other researchers reported high variability in the profit margins coming from the customers (Dalci et al., 2010; Everaert et al., 2008), the TD-ABC model in this research suggests that the seven branches contributed to the profitability of Speedy more consistently. This consistency is attributed to the fact that all seven branches bought the same products and services from Speedy. Although the profitability variation’s spectrum in this study was by far shorter than what has been reported in other studies such as (Dalci et al., 2010; Everaert et al., 2008), it can be seen as a strong indicator that the customer behaviour in the service companies is the most significant determinant of the customer profitability, which confirms (Anderson & Kaplan, 2007, p. 201) claim that customer profitability analysis is more important in the services companies than the product profitability analysis.

TD-ABC vs. the P&L statement

According to (Christopher, 2016), most companies still use conventional accounting systems. Such systems fail to measure the true cost-to-serve of customers in flow-oriented businesses, such as logistics companies because they still focus on product profitability rather than customer profitability. The P&L statement, for example, provides vertical function-based cost information, which is not adequate for evaluating customers profitability. Even with a customer-based P&L statement, the customer profitability information lacks details as it is limited to the gross profit level (Christopher, 2016). In Speedy’s case, the financial accounting system captured the revenue and direct costs associated with Hummy’s operation through the P&L statement. However, the details included in that statement were not enough to identify the relationship between the revenue generated by the customer and the actual resources consumed. Accordingly, Speedy’s management could not determine whether the mark-up it added on the direct cost was proportionate with the volume of resources consumed by Hummy. The TD-ABC model, on the contrary, assigned the total cost of the customer service starting from the Demand Planning stage to the Invoicing stage according to the volume of customers’ consumption. With the availability of such insights, the decisionmakers can make informed decisions regarding pricing strategy, customer relations, capacity utilisation, or any business domain.

The TD-ABC vs SC

According to the finance department manager, Speedy used the SC model to assign overhead costs to customers when it needed to make strategic decisions. As seen in the previous chapter, this model uses one cost driver: the number of pallets. The allocated overhead costs, using this method, were overestimated compared to the TD-ABC model. Although there was no evidence to justify this overestimation, the cost information is distorted as they were built on a single-cost-driver system. The SC is not relevant to environments where multiple cost drivers are needed to reflect the changes in the operation volume (Vercio, 2008). Speedy provided a wide range of services to Hummy and others. The number of pallets as a cost driver can be used for a logistics company that offers warehousing service only, or it can be used by Speedy’s management to calculate the cost of warehousing service only. The other logistics services required different activities with multiple cost drivers, such as time, distance, and product dimensions. Thus, it's essential to use a more sophisticated costing system to incorporate those drivers together. Activities such as Demand Planning and Delivery were not identical regarding the resources needed. Thus, using a single cost driver as a determinant of allocation for such activities' costs distorts cost information. The TD-ABC, instead, can play this role successfully.

7.4 Improvement opportunities with the TD-ABC implementation

The TD-ABC model development requires a comprehensive analysis of the business process. In this research, the case company provided 11 integrated supply chain and logistics services. These services demanded a long process journey with around 97 steps in total. Critical data about these steps, such as durations, assignees, and orders, were collected and incorporated into the simulated cost system. The company's management can utilise such data to analyse and evaluate the current business process efficiency. Building simulated scenarios with the TD-ABC data is one of the successful strategies that can be used to improve the operational flow. Popat et al. (2018) verified this advantage by utilising the TD-ABC model data in identifying the best process strategy regarding resource allocation and workflow changes in the healthcare industry. The logistics industry is similar to the healthcare industry in terms of the complexity of the operation and the type of resources needed (e.g. personnel, spaces, and machines). Potential operational flow and resource allocation improvements can be obtained with the help of the TD-ABC system. Identifying unused capacity, which the TD-ABC system is capable of, is a powerful tool to best utilise the existing practical capacity. Managerial decisions regarding the acquisition, elimination, or rotation of resources along the supply chain can't be informatively made without an enabling cost system such as TD-ABC.

Another room for improvement when using the TD-ABC system is using the system data and information for benchmarking purposes. Speedy's case shows that multiple warehouses and teams provided similar services in different locations. The researcher presumed that the process and standard times for implementing any given activity were identical across those locations. In reality, there might be differences in implementation that cause discrepancies in the TD-ABC outcomes. Everaert et al. (2008) found noticeable differences in the standard picking activity times among four warehouses operating under one company's umbrella. Siguenza-Guzman et al. (2016) claim that adopting the TD-ABC methodology can assist management in assessing and comparing the process and standard times across locations. The researchers reported cost and time differences between two units that perform the same activities. The TD-ABC model was used as a means for performance assessment. The study results show an excellent capability inherited in the cost system to identify the source of discrepancies between the two units. Kaplan et al. (2014) state that this advantage in the TD-ABC system allows big companies with multiple locations to share best practices among those locations based on the outcomes of benchmarking analysis.

Finally, adopting the TD-ABC methodology increases the chance of finding more cost-reduction opportunities. The high visibility of cost information in the TD-ABC model allows users to point out the sources of resource bleeding. Adioti and Valverde (2013) used the TD-ABC system to analyse the process cost in a service company. The researcher discovered that 75% of the total overhead cost is derived from 30% of activities. The management can control costs by paying more attention to the expenditures of those causing activities. Popat et al. (2018) conducted a similar study and found that the TD-ABC model helped to reduce the cost by 14% in one department and by 7% in another. In this thesis, the outcomes of the TD-ABC model illuminated the distribution of costs along the supply chain. For example, it was clear that the delivery cost in Jeddah City was higher than in other cities. There are two explanations that TD-ABC can provide to us in this regard. First, Hummy's branches in Jeddah were far from Speedy's warehouse. The average distance travelled in Jeddah City during Q1-2021 was 2676 km per month, while it was 2190 km in Riyadh and 558 km in Dammam. Decisions from Speedy's management to control and manage this cost could include negotiation with Hummy's management to minimise the frequency of trips and to maximise the quantities of orders in each trip. Another explanation for the high delivery cost in Jeddah City is the high cost of renting trucks in Jeddah City. Most of Speedy's trucks operating in Jeddah were hired by a third party, and the average cost per truck in Q1-2021 was around SAR 8,200 per month. Comparing this figure with Riyadh's rented truck cost (SAR 4700), this cost was too high. Negotiation with the trucks rental companies, or the study of owning trucks could be considered by Speedy's management to cut some expenses off. Somapa et al. (2012) suggest that the TD-ABC system is beneficial as it illuminates the areas of higher expenses so managements can negotiate with the company's vendors.

7.5 Integration of TD-ABC with OBA practice in the 4PL's realm

A discussion of OBA as it relates to 4PL could significantly contribute to both theory and practice. The existing literature states that the OBA concept depends on a transparent relationship between suppliers and buyers with respect to finance where one or both parties share costs and other pertinent data openly and honestly (Romano & Formentini, 2012). Facilitated by a robust cost accounting system, this transparency ultimately works to reveal opportunities to reduce costs while fostering further resource development among network members (Kajüter & Kulmala, 2005). Nevertheless, six critical prerequisites—commitment, trust, communication quality, participation, coordination, and joint problem-solving—impact the realisation of these aims (Kulmala, 2002).

Practically speaking, Speedy engagement with Hummy is a true testament to the importance of OBA practice with respect to ensuring transparency and trust in financial transactions. The spirit of collaborative cooperation between Speedy and Hummy is grounded in information disclosure, especially content related to product and landed costs, facilitating lofty levels of transparency and trust. At a more granular level, Speedy's supply chain department received confidential product data from Hummy including ingredients, prices, and the suppliers' names and locations. The accounts department worked carefully to calculate product plus landed costs for each shipment, underscoring the critical role that accurate cost accounting plays for OBA.

As highlighted in this study, exploring OBA within the 4PL sector lays the groundwork for a basic understanding of cost-plus pricing: a unique model partially defined by a fixed mark-up on products bought or sold to clients without any warehousing, fulfilment, or delivery charges (a concept in fact not widely discussed in existing 4PL literature). By highlighting this pricing model in the 4PL realm, this research sheds light on the importance of adopting advanced costing systems that generate detailed reports about resource consumption. Speedy's management, as mentioned in Chapter 4, faced a downstream pressure from Hummy to reduce the agreed-upon mark-up in the next contract. The existing accounting system that Speedy adopted did not allow for helpful insights for the decision-makers. In the 4PL operations, the absence of cost data of the main activities in any 4PL such as warehousing, fulfilment, and delivery is risky. Therefore, this research suggests that embracing the cost-plus pricing model for the 4PL companies must be combined with adopting a sophisticated costing system.

It is possible to enhance cost transparency in OBA contracts by applying the TD-ABC model in a 4PL setting (as revealed in this study). Interplay between TD-ABC and OBA, meanwhile, clarifies how 4PL companies can enter into clear and cooperative financial relationships with clients; this study therefore not only helps solve the existing literature gap but also sets the table for future research to perform a deeper dive into open-book contracts and related logistics sector implications. Study findings are also primed to take conversations about 4PL services (and corresponding pricing models) to new heights as a new lens through which practitioners and academics alike can further explore and understand financial interplay between 4PL companies and their clients.

7.6 Strategic Performance and Profitability Framework (SPPF)

Companies must closely monitor operations in order to meet their strategic objectives, including profitability, in the face of complex logistics and supply chain activities. Considering this, the TD-ABC methodology is a powerful (and proven) tool to arm management with accurate cost information (Anderson & Kaplan, 2007). In concert with TD-ABC, the CPA can explore the net profit generated by each customer—with the BSC rounding out the bunch as a strategic approach to link company vision with operations. According to the researcher, the successful integration of TD-ABC, CPA, and BSC tools ultimately yields the proposed Strategic Performance and Profitability Framework (SPPF) which aims to illustrate the relationship linking day-to-day task costs to overarching company strategy (see Figure 7.3).

As mentioned earlier, the TD-ABC system has sophisticated ability to generate accurate cost and process information that benefit key decision-makers. Accordingly, the proposed SPPF will amplify TD-ABC system adoption benefits as this framework calls for the incorporation of cost and process data. For example, the SPPF suggests that relevant data produced by TD-ABC (including operating DC, per-delivery, and idle capacity costs) are primed for use as financial KPIs in the BSC. TD-ABC-generated process efficiency metrics can also pack a significant punch with respect to the BSC internal process perspective, helping not only to analyse process bottlenecks and areas for improvement but also streamline operational processes in accordance with company objectives.

Revenue and cost structures reflected by various types of customers are more easily understood with the CPA. Moreover, organisations can effectively sync up customer-centric strategies with financial and operational goals (utilising CPA-derived insights about customer profitability to develop customer KPIs in the BSC, for example) via SPPF integration. As for specific KPIs (e.g. customer profitability index, retention rate, and lifetime value), these are nothing short of critical in the work to evaluate the customer relationship effectiveness and then to align the same with financial and strategic goals in a broader sense.

Overall, the proposed SPPF champions a holistic strategy as companies strive to manage performance and analyse profitability while battling the complex intricacies associated with logistics and supply chain realms. By flawlessly incorporating robust cost and process content from TD-ABC, CPA-derived profitability insights, and the strategic alignment capacity of the BSC, the SPPF stands tall as an inclusive framework; businesses can thus leverage this to observe, appraise, and boost their performance with strategic objectives in mind, not only bolstering their ability to make sound decisions but also endorsing cross-organisational culture that values continuous development and tactical alignment. The end result is an endeavour that strives to achieve maximum profitability and gain a competitive edge in the dynamic 4PL world.

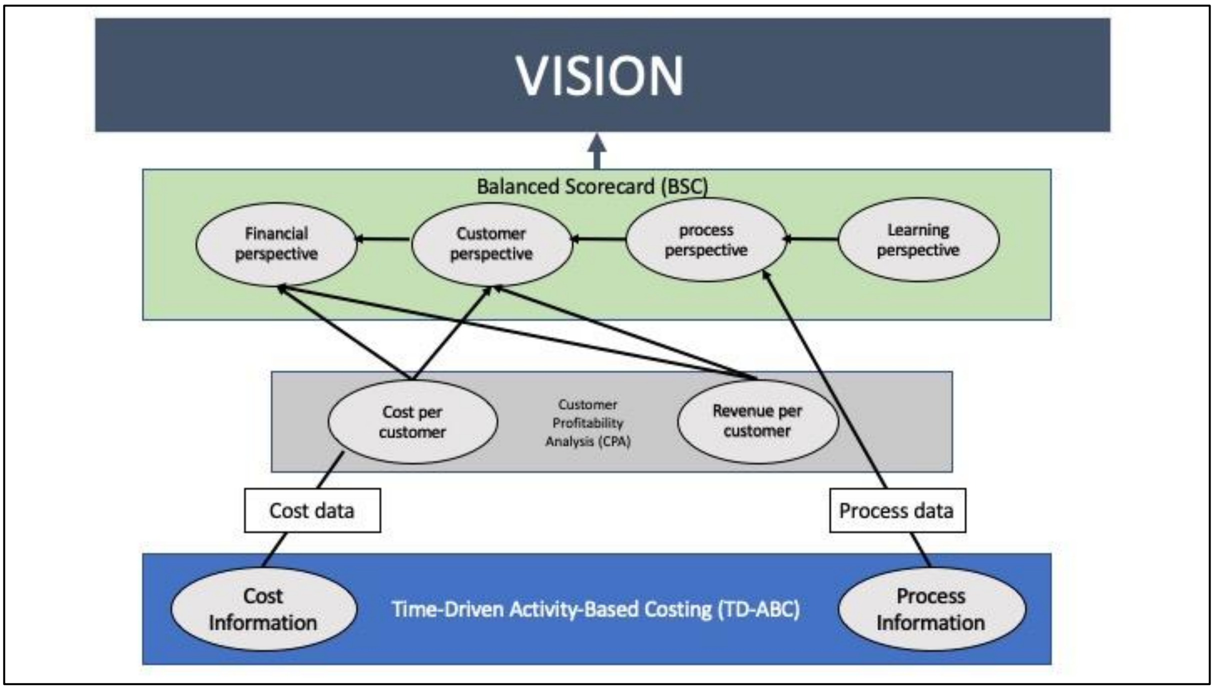

Figure 7-3: The Strategic Performance and Profitability Framework (SPPF)

Conclusion

This chapter discussed the development of a TD-ABC model for a Saudi-based logistics company that provides integrated supply chain services for its customers. The findings suggest that the TD-ABC model is suitable for complex supply chain operations. It assigns overhead costs to the cost objects in alignment with the resource consumption levels. However, the development of the TD-ABC model is not as straightforward as suggested in the literature. The model's accuracy demands the system designers to go the extra mile. Capacity information, activities, and times data should be collected analytically rather than randomly.

The TD-ABC and ABC systems are different in modelling the cost of supply chain activities. The findings of this comparison support the previous studies that claim that the TD-ABC system generates more accurate cost information than the ABC system. Although the two systems follow the same method in some development steps, the superiority of the TD-ABC model lies in its capability to isolate the unused capacity cost from the total cost allocated to the cost objects. In addition, the TD-ABC model showed more flexibility for updates and maintenance, while the ABC model showed more subjectivity to errors.

The researcher discussed how the TD-ABC methodology could enhance the quality of cost and profit reports. Thus, it can support management in making sound decisions. The logistics companies are service providers. It has been argued that customer profitability analysis for service-based businesses is more important than product profitability. This research supports this argument as it shows how one customer can contribute more to the company’s bottom line even if it has less business volume than other customers, and vice versa. The TD-ABC system's ability to allocate cost to customers accurately helps enhance the quality of the profitability reports. This advantage is not available in traditional systems. The P&L statement fails to explain the relationship between customers and activities, and the standard costing system is unsuitable for activities requiring different types of resources.

Revealing innovative learnings about pricing models popular among 4PL companies, this study also shines a light on the open-book contract model partially defined by a cost-plus pricing approach. This novel tactic features a fixed mark-up on client product transactions without any warehousing, fulfilment, or delivery charges. This concept is largely absent from existing literature addressing 4PL services. By performing a deep dive into this pricing approach, the study highlights a 4PL company’s operations using an open-book contract, thus offering fresh insight into financial and operational dynamics that help define this model. With the future in view, this study’s findings will be particularly useful to bolster discussions surrounding 4PL services and pricing models as a new lens through which both practitioners and scholars can further assess and better comprehend financial dealings between businesses in the 4PL industry and their clients. Moreover, this study will not only help address existing literature gaps (as noted above) but also set the table for future researchers to dive deeper into open-book contracts and related logistics industry implications. By further exploring operational tasks and financial approaches relative to this model, this research ultimately acts as a means to engage in additional analysis and enjoy an enhanced understanding of advanced 4PL pricing strategies by taking the current body of knowledge within the worlds of management accounting and supply chain management and adding an additional layer to this content.

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Chapter 8 : Conclusion

8.1 Summary of main findings

RQ1 – How can the TD-ABC system model the costs of integrated logistics services in a 4PL company?

The TD-ABC is a suitable and robust system for complex operations such as supply chain. It can trace and allocate overhead costs to the cost objects based on the exact volume of resources consumed by those objects. However, the TD-ABC modelling process is not as easy as promoted by its innovators and some researchers. The over-simplicity suggested, in theory, could lead to cost distortion. The researcher disagrees with the random techniques suggested by (Anderson & Kaplan, 2007) to estimate the practical capacity and activities times. This study suggests that there will be unjustified differences in the results compared to the alternative mathematical and observational ways. The mathematical and observational techniques are more accurate paths to collect TD-ABC data, although they are time-consuming. Researchers need several observational sessions to capture the process and average the standard times.

The supply chain activities are not homogeneous in the type of resources they consume. When integrating them under one cost system, the system designer should be careful in determining the number of resource pools. The example of warehouses in this study shows how one warehouse had to be divided into multiple pools based on the type of resources needed. In general, more resource pools lead to reduction in the chance of aggregation errors.

The financial accounting system should have a sound and detailed structure to get more accurate cost information from the TD-ABC model. The proper use of accounts charts, cost centres, and divisions when recording economic events can significantly help the cost system designer allocate resource expenses to the resource pools. Thus, the TD-ABC model can generate more reliable and accurate information. Moreover, without advanced technology such as WMS and ERP systems, it's hard to develop a robust TD-ABC model that sustains for a long time. Such systems can automatically reflect changes in the work settings in the cost system.

The chance of losing cost information accuracy increases when an activity requires a longer process across multiple pools. In logistics, one service could pass multiple stations before it gets done. The cost system should be capable of consolidating the cost numbers across those stations to generate accurate activity-level cost information.

RQ2 – How will the cost information generated from the TD-ABC system differ from those generated from the traditional ABC system?

The TD-ABC and ABC systems show different allocation methods. While the former allocates only the used capacity cost to the cost objects, the latter allocates both used and unused capacity costs to the cost objects. The researcher agrees with the previous studies that this is a significant distinction that outweighs the TD-ABC over the ABC system. In addition, the ABC system shows more maintenance and update process complexity as it consists of more cost drivers than the TD-ABC one. The example of complexity in Claims Management activity in this research supports the previous researchers' claims who reported this issue. Finally, the ABC system is subject to participant bias when estimating the workload distribution among activities. This flaw has been reported in previous studies and confirmed in this research as a serious flaw.

RQ3- How can the TD-ABC model help logistics companies improve the quality of the cost and profitability reports?

The TD-ABC system is an excellent tool for customer profitability analysis. It can allocate overhead costs to a customer based on how much resources consumed by that customer. Customer behaviour significantly influences service-based companies' profitability. Using the TD-ABC model for customer profitability analysis gives management more visible information about each customer's performance. The P&L statement fails to explain the cost-to-serve per each customer. The standard costing system is suitable for activities with one or limited cost drivers. In integrated supply chain activities, where the operation gains more complexity, this system fails to capture the true cost-to-serve. Thus, based on the standard system, the cost and profit reports are distorted because of their irrelevance to the operation settings.

8.2 Research Contributions

This research aims to offer new contributions to theory and practice in management accounting and supply chain management disciplines. Starting from the project scope, which includes a wide range of supply chain and logistics services, this research provides fresh insights into the advanced operational activities of logistics companies, especially those that provide 4PL services. Previous studies paid attention to the role of TD-ABC in a shorter spectrum within logistics. Most studies, such as (Afonso & Santana, 2016; Bahr & Price, 2016; Bruggeman et al., 2005; Everaert et al., 2008), focus on warehousing and distribution activities. This study explores the role of TD-ABC in an extended yet integrated supply chain. Services that come either before receiving shipments, such as Demand Planning and Procurement, or after, such as Claims Management and Invoicing, were all included in this study. This inclusion adds more value to future researchers who aim to study the new logistics services in more depth. The TD-ABC model developed for this integrated supply chain required rich data about process maps, steps, and times, which can be replicated for new investigations.

Since this research examines a variety of integrated supply chain services, it contributes to the theory of TD-ABC by identifying types of activities that may or may not efficiently align with the model's mechanism. The researcher observed typical logistics activities, such as Receiving Shipments, Picking & Loading, and Delivery, as well as advanced activities, such as Demand Planning and Procurement. One of the findings derived from these observations is that TD-ABC is more suitable for activities that involve physical movements rather than thinking, planning, or communicating. For example, the Demand Planning activity heavily depended on the SCS's forecasting of future sales. The researcher found difficulties in estimating this activity's times and steps. Moreover, since this activity involved communication and planning with other parties, the processing time could vary significantly. This research confirms (Cheporov & Cheporova, 2014) statement that TD-ABC could not be suitable for activities that require "forethought and creative thinking".

The third contribution of this research is that it empirically compares the requirements and challenges when developing TD-ABC and ABC systems from scratch. This contrasts with the previous studies, which primarily focus on the advantages and disadvantages of both systems (Cheporov & Cheporova, 2014; Hoozée et al., 2010; Zamrud & Abu, 2020). Since this research built simulation TD-ABC and ABC systems for the same case study using the same tool, it provides new insights into the similarities and differences between the two systems. For example, the researcher surveyed the SCS to estimate the workload distribution of activities. This survey was a mandatory step in developing the ABC system, while TD-ABC replaced this step with time equations. By comparing the outcomes of this survey with TD-ABC's outcomes, the researcher found that the estimates of the two systems were not aligned. The TD-ABC estimates were averaged from repeated observations. On the other hand, the ABC estimates represented participant' judgement. This misalignment could lead us to conclude that TD-ABC's outcomes are more reliable than ABC's since the latter depends on personal estimation, which is more prone to bias.

CPA stands as a primary benefit of implementing TD-ABC, particularly within the logistics sector. This study echoes the claim made by Anderson and Kaplan (2007) and Smith and Dikolli (1995) regarding its importance over the product profitability analysis in the service-based industries. The findings of this research show how the TD-ABC system can profoundly analyse customer profitability even if the customers buy the same products and consume the same resources. In previous studies, researchers compare profitability among customers representing different segments. On the contrary, this research compared the profitability of different branches under one customer's umbrella.

Echoing the literature, the complexity of serving a single client with multiple branches, each with its unique operational characteristics, is evident in this study's findings (Smith & Dikolli, 1995). Findings suggest that although branches' profitability is relatively consistent since they share similar characteristics, management can find room to improve the overall customer profitability based on the branches' profitability analysis. For example, this research shows that two branches were less profitable than the other five. These two branches were located in the same city, while the other five were in different cities. Such outcomes may lead to investigating the operational costs in the DC that serves the most costly branches. This granular understanding, as highlighted in the literature, can pave the way for tailored solutions, enhancing overall profitability and customer satisfaction (Shank & Govindarajan, 1993)

This research unveils a fresh perspective on the practice of OBA when adopted by 4PL companies, with a spotlight on the cost-plus pricing model. Unlike traditional pricing models, this unique model involves a fixed mark-up on the products bought and sold to clients, with no charges for warehousing, fulfilment, or deliveries. This model is especially significant as it is not widely discussed in existing literature concerning 4PL services. By diving deep into this pricing model, this research sheds light on how a 4PL company operates under an open-book contract, thereby offering new insights into the financial and operational dynamics inherent in such an arrangement.

A focal point of this study is the TD-ABC model and its demonstrated efficacy in heightening transparency for open-book contract costs. This aligns with insights from Caglio (2018) and the recommendations of Seal et al. (1999) that claim that the successful OBA practice demands sophisticated costing systems between the supply chain partners. Furthermore, this research underscores the avenues through which 4PL entities can build transparent and synergistic ties with their clientele. These revelations serve to bridge existing scholarly gaps, especially in the realm of 4PL financial operations, as evidenced by sectors like automotive (Fehr & Rocha, 2018) and manufacturing (DhaifAllah et al., 2019). Consequently, this investigation stands as a foundational reference for subsequent inquiries into the fiscal dynamics of 4PL offerings, contributing to the broader conversations in supply chain management and management accounting.

Finally, in the world of logistics, companies are always looking for advanced ways to measure their work and plan for the future. This research has suggested many new ideas to help logistics companies in this area. One idea is the SPPF. The SPPF brings together three tools: TD-ABC, CPA, and

BSC. But the SPPF is just a starting point. It is an idea for future researchers who want to see how costs connect with a company's big goals. For companies in the 4PL area, the SPPF might be a helpful guide that links the day-to-day operational activities and data with the company's strategic goals.

8.3 Research Limitations and Future Research Opportunities

This research aims to discover the role of the TD-ABC methodology in modern logistics companies. The researcher developed a simulating TD-ABC model from scratch to investigate how this methodology can model the supply chain costs. The research scope was limited to a short period, one location (out of five), and one customer (out of fifteen).

First, the researcher observed operational activities and collected operational and financial data for three months, from January to March 2021. Seasonality is a critical factor in logistics as it could impact the operational process (Sanchez-Rodrigues et al., 2010). The selected period may not capture the whole picture of operations. Steps and durations may differ from one season to another. Nonetheless, the researcher was compelled to concentrate on this short period for his analysis due to the lack of access to sophisticated analysis software capable of constructing TD-ABC and ABC models with extensive datasets. Instead, he used Microsoft Excel spreadsheets to build these simulated models. Future researchers may consider an extended time scope to study the impact of seasonality on activities, times, and capacity utilisation when applying TD-ABC.

Second, the researcher conducted this study in the central warehouse and the head office of the case company. The operations in that warehouse were presumed to be identical to the other four unobserved locations. Accordingly, the researcher used the observation outcomes to build the TD-ABC equations for all locations. Other researchers may find it worth observing each location individually. Such elaboration enables more information accuracy and insights into the locations' performance and will enable researchers and managers to use the TD-ABC model as a tool for benchmarking.

This study did not discuss the organisational issues and the success and failure factors when implementing TD-ABC system. The reason behind this silence is that this research developed a simulated TD-ABC model using Excel spreadsheets on a small but representative scale. This limitation prevented the researcher from exploring real organisational issues and factors that may influence the success and failure of this model's implementation. Therefore, the future researchers may consider this domain in their studies if they aim to discover the implementation of a real TD-ABC systems in the 4PL space.

Last but not least, this research investigated the operation for only one case customer. This limitation is because this customer was the only suitable customer for this research's aims. Although the researcher diluted this limitation by counting on the branches of this customer as different objects, the impact of this limitation is still noticeable in some aspects of the research. For example, this research does not provide the best leverage for the role of the TD-ABC methodology in calculating the unused capacity cost in most resource pools. The non-investigated capacity was preserved for other customers, and some of it represented the actual idle capacity.

This research calls for future researchers to investigate the impact of TD-ABC's reports on management decisions. For example, the variation in resource consumption among branches in this research resulted in variation in profitability. Future researchers may study the reactions of decisionmakers to deal with branches with lower margins. Another example is the HED-SC resource pool, where the resources were dedicated to only one customer. The capacity utilisation rate in that pool was low. Therefore, it could be interesting to go further and discover the management's opinion about this scenario. Researchers may investigate how managements allocate the unused capacity cost in such cases. Should this unused capacity's cost be allocated to the causing customer, or it should be unassigned cost?

Although the TD-ABC model developed in this research succeeded in capturing all integrated supply chain processes in the case company, starting from the supplier-related activities to the customer-related ones, this research doesn't focus on the relation between the case company and suppliers, and the impact of that relationship on the total cost. This research, due to the time limitation, couldn't investigate the details of all POs and it assumed that all these POs followed the same pathway with no variations. Other scholars may define this as another limitation to the study's scope. In this perception, new research could be conducted to explore supplier cost analysis under the TD-ABC model.

The time equations inherit in TD-ABC show an evident superiority over the traditional costing systems such as SC and ABC. Future researchers may explore the application of these equations for strategic initiatives in supply chain management. For example, variability and scenario analyses are vital to improve the process of the supply chain. The time equations can facilitate more precise analyses since they dig deep in the process, which can eventually assist in eliminating waste and focus on the value-added activities. This research has presented a TD-ABC model that incorporates time equations for 11 supply chain and logistics activities. Future researchers can use this model and expand equations to build more complex scenarios. This feature will contribute greatly to the supply chain and management accounting literature. The BSC is another strategic tool that has been studied with the TD-ABC system in many domains but not in the supply chain arena. Future researchers may use the time equations to evaluate the four perspectives of the BSC (financial, customer, internal process, and learning and growth perspectives). The researchers may suggest more relevant KPIs for these four perspectives based on the TD-ABC outcomes.

Finally, although exploring OBA within the 4PL sector offers a basic and functional understanding of the cost-plus pricing model (as highlighted in this research), there is a room to further explore a wider breadth of financial modelling and analysis perspectives. Future researchers are implored to perform a deeper dive into the integration of TD-ABC with OBA practices within the 4PL arena. Additional investigations into how TD-ABC can augment transparency, cost-efficiency, and operational effectiveness in open-book contracts will pave the way for invaluable insights. In addition, as for a different approach, performing a comparative assessment between TD-ABC, traditional ABC, and other costing models in both open- and closed-book contracts within the 4PL environment can also stand to further cultivate newfound knowledge surrounding financial dynamics in this industry.

Conclusion

The world of business, nowadays, has become more competitive and intensive than ever. With the emergence of new business models, companies have shifted from doing all activities internally to outsourcing those requiring a different set of competencies and skills. Companies from all different industries tend to outsource logistics activities to logistics providers who have become more significant players in the value chain than before. This trend, consequently, has developed intense pressure on those providers who aim to satisfy their customers with the best services at the lowest possible rates. However, this aim is not easy to meet. The logistics operation is complicated, and it requires many resources. Failure to accurately calculate these resources' cost leads to negative results.

Many costing systems and models have been discussed in the management accounting literature. One of the most popular systems is SC. It is a simple yet efficient system. It was relevant at the beginning of the industrial revolution when direct costs (e.g. labour costs) were more significant than indirect ones. However, with the expansion of organisations' size, this system became invalid for the new business models. Management consultants invented the ABC system that allocates overhead costs to cost objects based on the activities each object requires. This advantage has given ABC publicity as it allowed for more accurate cost information than SC.

However, many companies abandoned ABC quickly. Determining activities involved in serving cost objects can be seen as a hassle. It requires periodic surveys from those who are involved in the operation. In addition, it requires a massive database of activities and cost drivers, which means high maintenance and updates costs. Therefore, Kaplan and Anderson (2004) innovated TD-

ABC to overcome these drawbacks found in ABC. The TD-ABC system shares the main idea of ABC, which is the employment of activities as a hub of allocation, but it differs from ABC by using time equations instead of surveys. By configuring time equations into the system, users can automatically estimate the overhead cost allocated to cost objects based on the time consumed by each object. Kaplan and Anderson (2004) claim that this mechanism helps companies calculate their overhead costs accurately, even in complex settings, such as logistics.

This research aims to examine the superiority of TD-ABC in complex settings by developing a TD-ABC system for a 4PL logistics company. The company offers services such as Demand Planning, Procurement, Warehousing, Order Fulfilment, and Delivery that require different resources. Workers, trucks, spaces, and equipment costs should be allocated accurately to the customers, branches, orders, products, and more. Such complexity requires a sophisticated costing system. The researcher aimed to explore how these costs can be modelled under the TD-ABC system. He developed a TD-ABC model to capture and allocate such costs to the different cost objects. In addition, he developed an ABC model to compare it with the former in terms of the development process and outcomes. Finally, the researcher used the developed TD-ABC model to analyse the customer profitability to explore its capability to enhance the quality of profitability reports compared with traditional reports, such as P&L and SC reports.

To meet the aforementioned research aims, the researcher used the single-case study methodology. This approach is powerful in understanding events in their context. The researcher collected data from one case company through multiple means. First, he implemented semi-structured interviews with the case company's top management and department heads. These interviews aimed to understand the business model, processes, resources, services, customers, and more. Next, the researcher observed the operational processes for three months. He collected data for times, steps, and resources needed to perform each activity. Next, he collected documents from the company's ERP system that were necessary to develop TD-ABC and ABC systems. Microsoft Excel was used to build simulation models and analyse the operational and financial transactions in Q1-2021. This study reveals that TD-ABC offers greater accuracy than ABC in calculating the cost of logistics operations. The TD-ABC system successfully allocated overhead costs to the cost objects based on the actual consumption of resources. On the other hand, ABC overestimated the costs allocated to the cost objects as it includes both productive and idle capacity costs. The TD-ABC system showed superiority over the traditional systems in providing high-quality reports for customer profitability. Within logistics companies, the cost-to-serve report holds significant value. Customer profitability varies not only based on services or products they demand but also based on their behaviour. This research indicated that TD-ABC effectively traced the customer behaviour and generated accurate profitability reports in response.

The outcomes of this research could have several implications for both theory and practice. First, logistics activities are complex, especially with the expansion of services. Calculating the overhead costs accurately is a challenge for logistics companies. TD-ABC is a powerful tool for that. However, this tool requires vast data and effort to generate accurate outcomes. Researchers and practitioners should not oversimplify the process of TD-ABC development. Random selections and interviews for time estimations could impact the quality of outcomes. Secondly, TD-ABC can be used for other purposes besides costing, such as business process improvement and benchmarking. The rich data generated or collected by the TD-ABC system are helpful for management to improve operations. For example, TD-ABC can be used to identify the idle capacity in a specific department. Accordingly, management can decide to either reduce the allocated resources or accept more businesses. Researchers and practitioners can use the TD-ABC system for customer profitability analysis. This system can distinguish between profitable and losing customers based not only on the volume of business but also on customer behaviour. Building on this, the proposed SPPF serves as a potential avenue for future research while aiming to further connect granular cost data with strategic objectives, especially in the 4PL context. It also underscores the importance of an integrated approach in looking to understand and optimise performance and profitability. Finally, exploring OBA within the 4PL sector in this study enriches the theoretical understanding of cost transparency and pricing models in logistics, bridging a notable gap in existing literature.

References

Abdur Razzaque, M., & Chen Sheng, C. (1998). Outsourcing of logistics functions: a literature survey. *International Journal of Physical Distribution & Logistics Management*, *28*(2), 89-107. https://doi.org/10.1108/09600039810221667

Adıgüzel, H. (2023). Increasing the efficiency of delivery operations and customer profitability analysis with a time-driven activity-based costing model. *Emerald Emerging Markets Case Studies*, *13*(1), 1-17.

Adioti, A. A., & Valverde, R. (2013). Time-Driven Activity Based Costing for the Improvement of IT Service Operations. *International Journal of Business and Management*. https://doi.org/10.5539/ijbm.v9n1p109

Afonso, P., & Santana, A. (2016). Application of the TDABC model in the logistics process using different capacity cost rates. *Journal of Industrial Engineering and Management*, *9*, 1003-1019. https://doi.org/10.3926/jiem.2086

Anderson, J. C., & Narus, J. A. (1998). Business marketing: understand what customers value. *Harvard business review*, *76*, 53-67.

Anderson, S., & Kaplan, R. (2007). *Time-driven activity-based costing: a simpler and more powerful path to higher profits* (Vol. 82). Harvard Business School Press Books. https://doi.org/10.1080/09638180701814171

Anderson, S. W., & Widener, S. K. (2006). Doing Quantitative Field Research in Management Accounting. *Handbooks of Management Accounting Research*, *1*, 319-341. https://doi.org/10.1016/S1751-3243(06)01012-1

Au, J., & Rudmik, L. (2013). Cost of outpatient endoscopic sinus surgery from the perspective of the Canadian government: a time-driven activity-based costing approach. International forum of allergy & rhinology,

AYRANCI, A. E., & Gizem, A. (2022). Examination of the Relationship between Stock Management and Profitability in Businesses: An Application on Borsa Istanbul Manufacturing Companies. *Ekonomi Politika ve Finans Araştırmaları Dergisi*, *7*(4), 839-854.

Ayyildiz, E., & Taskin Gumus, A. (2021). Interval-valued Pythagorean fuzzy AHP method-based supply chain performance evaluation by a new extension of SCOR model: SCOR 4.0. *Complex & Intelligent Systems*, *7*, 559-576.

Bahr, W. (2016). *Radio frequency identification and time-driven activity based costing: RFID-TDABC* [Ph.D., Aston University].

Bahr, W., & Price, B. (2016). Radio Frequency Identification and Time-Driven Activity Based Costing : Rfid-Tdabc Application in Warehousing. *21st Annual Logistics Research Network Conference, Chartered Institute of Logistics and Transport*.

Baker, J. J. (1998). Activity-based costing and activity-based management for health care.

Baker, P., & Canessa, M. (2009). Warehouse design: A structured approach. *European Journal of Operational Research*, *193*, 425-436. https://doi.org/10.1016/j.ejor.2007.11.045

Balakrishnan, R., Hansen, S., & Labro, E. (2011). Evaluating heuristics used when designing product costing systems. *Management Science*, *57*(3), 520-541.

Ballou, R. H. (2007). The evolution and future of logistics and supply chain management. *European Business Review*, *19*, 332-348. https://doi.org/10.1108/09555340710760152

Barrett, R. (2005). Time-driven costing: The bottom line on the new ABC. *Business Performance Management*, *11*, 35-39.

Bennett, A., & George, A. L. (2005). *Case Studies and Theory Development in the Social Sciences*. MIT Press.

Berglund, M., van Laarhoven, P., Sharman, G., & Wandel, S. (1999). Third-Party Logistics: Is There a Future? *International Journal of Logistics Management, The*, *10*, 59-70. https://doi.org/10.1108/09574099910805932

Bhagwat, R., & Sharma, M. K. (2007). Performance measurement of supply chain management: A balanced scorecard approach. *Computers & industrial engineering*, *53*(1), 43-62.
Bjørnenak, T., & Mitchell, F. (2002). The development of activity-based costing journal literature, 1987-2000. *European Accounting Review*, *11*, 481-508. https://doi.org/10.1080/0963818022000001019
Blaschke, B. L., Parikh, H. R., Vang, S. X., & Cunningham, B. P. (2020). Time-Driven Activity-Based Costing: A Better Way to Understand the Cost of Caring for Hip Fractures. *Geriatr Orthop Surg Rehabil*, *11*, 2151459320958202. https://doi.org/10.1177/2151459320958202
Boysen, N., de Koster, R., & Weidinger, F. (2019). Warehousing in the e-commerce era: A survey. *European Journal of Operational Research*, *277*(2), 396-411. https://doi.org/10.1016/j.ejor.2018.08.023
Bragg, S. M. (2013). *Accounting best practices*. John Wiley & Sons.
Bruggeman, W., Everaert, P., Anderson, S. R., & Levant, Y. (2005). Modeling Logistics Costs using Time-Driven ABC: A Case in a Distribution Company. In: Ghent University, Faculty of Economics and Business Administration.
Bryman, A. (2016). *Social Research Methods 5th Edition*. Oxford university press.
Caglio, A. (2018). To disclose or not to disclose? An investigation of the antecedents and effects of open book accounting. *European Accounting Review*, *27*(2), 263-287.
Cardinaels, E., & Labro, E. (2008). On the determinants of measurement error in time-driven costing. *The Accounting Review*, *83*(3), 735-756.
Cheporov, V., & Cheporova, G. (2014). ABC vs TD-ABC for higher education: case studies. *Ученые записки Крымского федерального университета имени ВИ Вернадского. Экономика и управление*, *27*(1), 166-178.
Christopher, M. (1999). *Logistics and Supply Chain Management: Strategies for Reducing Cost and Improving Service.* Pitman Publishing.
Christopher, M. (2016). *Logistics and Supply Chain Management, 5th edition*. Pearson Education. https://books.google.com.sa/books?id=vWNxjgEACAAJ
CIPS Australaisa. (2013). *The Definitions of 'Procurement' and 'Supply Chain Management'*.
Collin, J., & Eloranta, E. (2009). How to design the right supply chains for your customers. *Supply Chain Management*, *14*(6), 411-417. https://doi.org/https://doi.org/10.1108/13598540910995174
Compton, T. R. (1996). Implementing activity-based costing. *The CPA Journal*, *66*(3), 20.
Cooper, M. C., Lambert, D. M., & Pagh, J. D. (1997). Supply Chain Management: More Than a New Name for Logistics. *The International Journal of Logistics Management*, *8*(1), 1-14. https://doi.org/10.1108/09574099710805556
Cooper, R. (1990). Implementing an activity-based costing system. *Journal of Cost Management* 33-42.
Cooper, R., & Kaplan, R. (1992). Activity-Based Systems: Measuring the Costs of Resource Usage. *Harvard business review*, *6*, 96-103.
Cooper, R., & Kaplan, R. S. (1991). Profit priorities from activity-based costing. *Harvard business review*, *69*(3), 130-135.
Copacino, W. C. (2019). *Supply chain management: The basics and beyond*. Routledge. https://doi.org/https://doi.org/10.4324/9780203737859
Coyle, J. J., Langley, C. J. J., Novack, R. A., & Gibson, B. J. (2013). *Managing Supply Chains: A Logistics Approach*. South-Western, Cengage Learning.
Cranage, D. A., & Andrew, W. P. (1992). A comparison of time series and econometric models for forecasting restaurant sales. *International Journal of Hospitality Management*, *11*(2), 129-142.
Creswell, J., & Plano Clark, V. (2007). *Designing and Conducting Mixed Methods Research*. Sage Publications https://doi.org/10.1177/1094428108318066

Creswell, J. C. (2009). Choosing a Mixed Methods Design. Designing and Conducting Mixed Methods Research,

Croxton, K. L. (2003). The Order Fulfillment Process. *The International Journal of Logistics Management*, *14*, 19-32. https://doi.org/10.1108/09574090310806512

Croxton, K. L., And, S. J. G.-D. T., Douglas Lambert, M., & Rogers, D. S. (2001). The Supply Chain Management Processes. *International Journal of Logistics Systems and Management*, *12*, 13-36. https://doi.org/10.1108/09574090110806271

Daim, T. U., Udbye, A., & Balasubramanian, A. (2013). Use of analytic hierarchy process (AHP) for selection of 3PL providers. *Journal of Manufacturing Technology Management*, *24*, 28-51. https://doi.org/10.1108/17410381311287472

Dalci, I., Tanis, V., & Kosan, L. (2010). Customer profitability analysis with time-driven activity-based costing: a case study in a hotel. *International Journal of contemporary hospitality Management*, *22*(5), 609-637.

Damme, D. A. v., & Amstel, M. J. (1996). Outsourcing logistics management activities. *The International Journal of Logistics Management*, *7*(2), 85-94.

Danomah, F. (2021). Assessing Financial Efficiency with Time-Driven Activity-Based Costing (TDABC) Model: Evidence from International Trading Companies

. *Journal of Resources Development and Management*, *76, 2021*, 1-15. https://doi.org/10.7176/JRDM/76-01

Datar, S., & Gupta, M. (1994). Aggregation, Specification and Measurement Errors in Product Costing. *The Accounting Review*, *69*(4), 567-591. http://www.jstor.org/stable/248432

Dejnega, O. (2011). Method Time Driven Activity Based Costing– Literature Review. *Journal of Applied Economic Sciences*, *VI*, 5-15.

Delipinar, G. E., & Kocaoglu, B. (2016). Using SCOR model to gain competitive advantage: A Literature review. *Procedia-Social and Behavioral Sciences*, *229*, 398-406.

Demeere, N., Stouthuysen, K., & Roodhooft, F. (2009). Time-driven activity-based costing in an outpatient clinic environment: development, relevance and managerial impact. *Health policy*, *92*(2-3), 296-304.

DhaifAllah, B., Auzair, S. M., Maelah, R., & Ismail, M. D. (2019). Measuring inter-organizational cost management and open book accounting. *Jurnal Pengurusan*, *22*.

Dissanayake, C. K., & Cross, J. A. (2018). Systematic mechanism for identifying the relative impact of supply chain performance areas on the overall supply chain performance using SCOR model and SEM. *International Journal of Production Economics*, *201*, 102-115.

Ellram, L. M. (1996). The use of the case study method in logistics research. *Journal of Business Logistics*, *17*(2), 93.

Eriksson, P. E., & Westerberg, M. (2011). Effects of cooperative procurement procedures on construction project performance: A conceptual framework. *International journal of project management*, *29*(2), 197-208.

Everaert, P., & Bruggeman, W. (2007). Time-driven activity-based costing: Exploring the underlying model. *Cost Management*, *21*, 16-20.

Everaert, P., Bruggeman, W., Sarens, G., Anderson, S. R., & Levant, Y. (2008). Cost modeling in logistics using time-driven ABC. *International Journal of Physical Distribution & Logistics Management*, *38*, 172-191. https://doi.org/10.1108/09600030810866977

Faber, N., de Koster, M. B. M., & Smidts, A. (2013). Organizing warehouse management. *International Journal of Operations and Production Management*, *33*, 1230-1256. https://doi.org/10.1108/IJOPM-12-2011-0471

Farahani, R. Z., Rezapour, S., & Kardar, L. (2011). Logistics Operations and Management, Concepts and Models. *Journal of Chemical Information and Modeling*. https://doi.org/10.1017/CBO9781107415324.004

Fawcett, S. E. (2000). *Logistics, in meeting customer needs*. Springer US.

Fehr, L. C. F. d. A., & Rocha, W. (2018). Open-book accounting and trust: influence on buyer-supplier relationship. *RAUSP Management Journal*, *53*, 597-621.
Feilzer, M. Y. (2010). Doing mixed methods research pragmatically: Implications for the rediscovery of pragmatism as a research paradigm. *Journal of Mixed Methods Research*, *4*, 6-16. https://doi.org/10.1177/1558689809349691
Fisher, M. (1997). What is the right supply chain for your product. *Harvard business review*, *75*, 105-117.
Fitzgerald, J. A. (2007). "Six Essential Strategies for Selecting a Global 3 PL". *Inbound Logistics*, *27*, 34-35.
Fleischman, R. K., & Tyson, T. N. (1998). The evolution of standard costing in the UK and US: from decision making to control. *Abacus*, *34*(1), 92-119.
Flick, U. (2018). *Managing Quality in Qualitative Research* (Second ed.). SAGE Publications Ltd. https://doi.org/10.4135/9781849209441
Flick, U., Maxwell, J. A., & Chmiel, M. (2014). Generalization in and from Qualitative Analysis. *The SAGE Handbook of Qualitative Data Analysis*, *7*(37), 540-553. https://doi.org/10.4135/9781446282243.n37
Flyvbjerg, B. (2001). Making Social Science Matter. Why Social Inquiry Fails and How It Can Succeed Again. *Revue Française de Sociologie*, *44*, 148. https://doi.org/10.2307/3323112
Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, *12*, 219-245. https://doi.org/10.1177/1077800405284363
Forrester, J. W. (1958). Industrial Dynamics. A Major Breakthrough for Decision Makers. *Harvard business review*, *36*, 37-66.
Freichel, S. L., Rütten, P., & Wörtge, J. K. (2022). Challenges of supply chain visibility in distribution logistics–a literature review. *Ekonomski vjesnik: Review of Contemporary Entrepreneurship, Business, and Economic Issues*, *35*(2), 453-466.
Fylan, F. (2005). Semi-structured interviewing. In *A Handbook of Research Methods for Clinical and Health Psychology* (pp. 65-77). Oxford University Press. (Oxford University Press)
Gabriel, D. H., & Parthiban, M. (2020). A Literature Review on Global Challenges for Third Party Logistics (TPL or 3PL). *Asian Review of Mechanical Engineering*, *9*(2), 27-30.
Gattorna, J. (2010). *Dynamic Supply Chains: Delivering Value Through People* (Second Edition ed.). Prentice Hall.
Gaudenzi, B., Confente, I., & Russo, I. (2020). Logistics service quality and customer satisfaction in B2B relationships: a qualitative comparative analysis approach. *The TQM Journal*, *33*(1), 125-140.
Gen, M., Anudari, C., & Yun, Y. (2021). Hybridizing teaching-learning based optimization with GA and PSO: Case study of supply chain network model. 2021 International Conference on Computational Science and Computational Intelligence (CSCI),
Gencer, Y. G. (2019). Supply Chain Modernization: The Case of Turkish Companies in 3PL and 4PL Logistics Applications. In *The Circular Economy and Its Implications on Sustainability and the Green Supply Chain* (pp. 168-176). IGI Global.
Gerring, J. (2004). What Is a Case Study and What Is It Good for? Source: The American Political Science Review,
Gervais, M., Levant, Y., & Ducrocq, C. (2010). Time-Driven Activity-Based Costing (TDABC): An Initial Appraisal through a Longitudinal Case Study. *Journal of Applied Management Accounting Research*, *8*, 1-20.
Geurts, M. D., & Patrick Kelly, J. (1986). Forecasting retail sales using alternative models. *International Journal of Forecasting*, *2*(3), 261-272. https://doi.org/https://doi.org/10.1016/0169-2070(86)90046-4
Gibbert, M., Ruigrok, W., & Wicki, B. (2008). What passes as a rigorous case study? *Strategic Management Journal*, *29*(13), 1465-1474. https://doi.org/10.1002/smj.722

Gonzalez, M., Nachtmann, H., & Pohl, E. (2017). Time-driven activity-based costing for health care provider supply chains. *The Engineering Economist*, *62*(2), 161-179. https://doi.org/10.1080/0013791X.2016.1264035

Govindan, K., Khodaverdi, R., & Vafadarnikjoo, A. (2016). A grey DEMATEL approach to develop third-party logistics provider selection criteria. *Industrial Management and Data Systems*, *116*(4), 690-722.

Grazia, S. M. (2018). Trends in transportation and logistics. *European Journal of Operational Research*, *264*, 830-836. https://doi.org/10.1016/j.ejor.2016.08.032

Gu, J., Goetschalckx, M., & McGinnis, L. F. (2007). Research on warehouse operation: A comprehensive review. *European Journal of Operational Research*, *177*, 1-21. https://doi.org/10.1016/j.ejor.2006.02.025

Gupta, M., Foster, G., & Sjoblom, L. (1997). Customer Profitability Analysis: Challenges and New Directions. *Journal of Cost Management*, *10*(1).

Gürcan, Ö. F., Yazıcı, İ., Beyca, Ö. F., Arslan, Ç. Y., & Eldemir, F. (2016). Third Party Logistics (3PL) Provider Selection with AHP Application. *Procedia - Social and Behavioral Sciences*, *235*, 226-234. https://doi.org/10.1016/j.sbspro.2016.11.018

Gustafsson, J. (2017). Single case studies vs. multiple case studies: A comparative study. Academy of Business, Engineering and Science Halmstad University, Sweden,

Håkansson, H., Kraus, K., & Lind, J. (2010). *Accounting in networks* (Vol. 7). Routledge.

Haldar, A., Qamaruddin, U., Raut, R., Kamble, S., Kharat, M. G., & Kamble, S. J. (2017). 3PL evaluation and selection using integrated analytical modeling. *Journal of Modelling in Management*, *12*(2), 224-242. https://doi.org/10.1108/JM2-04-2015-0016

Hanus, P. (2013). The business profile shaping and the logistics information systems of 2PL, 3PL, 4PL operators. *Journal of Economics & Management*, *12*, 5-21.

Harrison, H., Birks, M., Franklin, R., & Mills, J. (2017). Case study research: Foundations and methodological orientations. *Forum Qualitative Sozialforschung*, *18*(1), 1-17. https://doi.org/10.17169/fqs-18.1.2655

Helgesen, Ø. (2007). Customer accounting and customer profitability analysis for the order handling industry—A managerial accounting approach. *Industrial Marketing Management*, *36*(6), 757-769.

Hickson, A., Wirth, C. B., Comm Morales, B. G., & Comm, B. (2008). Supply Chain Intermediaries Study Prepared for: Manitoba Infrastructure and Transportation. *University of Manitoba Transport Institute*, *56*.

Ho, R. T. H., Ng, S. M., & Ho, D. Y. F. (2007). The Sage Handbook of Qualitative Research. Asian Journal Of Social Psychology,

Ho, T. H. D., Daniel, J., Nadeem, S. P., Garza-Reyes, J. A., & Kumar, V. (2018). Improving the reliability of warehouse operations in the 3PL Industry: An Australian 3PL case study. 2018 International Conference on Production and Operations Management Society (POMS),

Hoozée, S., Vanhoucke, M., & Bruggeman, W. (2010). *Comparing the accuracy of ABC and time-driven ABC in complex and dynamic environments: a simulation analysis* Ghent University, Faculty of Economics and Business Administration].

Hoozée, S., Vermeire, L., & Bruggeman, W. (2012). The Impact of Refinement on the Accuracy of Time-driven ABC. *Abacus*, *48*(4), 439-472.

Hugos, M. (2018). *Essentials of Supply Chain Management*. John Wiley & Sons, Inc. https://doi.org/10.1002/9781119464495

Huynh, T. T.-M., Dang, C. N., Le-Hoai, L., Pham, A.-D., & Nguyen, T. D. (2020). Proposing a strategy map for coastal urban project success using the balanced scorecard method. *Engineering, Construction and Architectural Management*, *27*(10), 2993-3030.

Hyett, N., Kenny, A., & Dickson-Swift, V. (2014). Methodology or method? A critical review of qualitative case study reports. *International Journal of Qualitative Studies on Health and Well-being*, *9, 23606*. https://doi.org/10.3402/qhw.v9.23606

Im, J., & Kurnia, S. (2013). Exploring the use and benefits of web 2.0 for supply chain management. ACIS 2013: Information systems: Transforming the Future: Proceedings of the 24th Australasian Conference on Information Systems,

Islam, D. M. Z., Fabian Meier, J., Aditjandra, P. T., Zunder, T. H., & Pace, G. (2013). Logistics and supply chain management. *Research in Transportation Economics*, *41*, 3-16. https://doi.org/10.1016/j.retrec.2012.10.006

Ittner, C., & Larcker, D. (2002). Empirical managerial accounting research: are we just describing management consulting practice? *European Accounting Review*, *11*, 787-794. https://doi.org/10.1080/0963818022000047082

Ittner, C. D., Larcker, D. F., & Meyer, M. W. (2003). Subjectivity and the weighting of performance measures: Evidence from a balanced scorecard. *The Accounting Review*, *78*(3), 725-758.

Jain J. K., Dangayach G.S., Agarwal G., & S., B. (2010). Supply Chain Management: Literature Review and Some Issues. *Journal of Studies on Manufacturing*, *1*(1), 11-25.

Järvinen, J., & Väätäjä, K. (2018). Customer Profitability Analysis Using Time-Driven Activity-Based Costing. Three Interventionist Case Studies. *The Nordic Journal of Business, Forthcoming*.

Johannesson, P., & Perjons, E. (2014). *An introduction to design science*. Springer International Publishing. https://doi.org/10.1007/978-3-319-10632-8

Johansson, R. (2007). On Case Study Methodology. *Open House International*, *32*(3), 48-54. https://doi.org/10.1108/OHI-03-2007-B0006

Johnson, H. T. (1972). Early Cost Accounting for Internal Management Control: Lyman Mills in the 1850's. *Business History Review*, *46*, 466-474. https://doi.org/10.2307/3113343

Johnson, H. T. (1992). It's time to stop overselling activity-based concepts. *Strategic Finance*, *74*(3), 26.

Johnson, T., & Kaplan, R. (1987). *Relevance Lost: The Rise and Fall of Management Accounting*. Harvard Business School Press. https://books.google.com.au/books?id=fZupPwAACAAJ

Jothimani, D., & Sarmah, S. P. (2014). Supply chain performance measurement for third party logistics. *Benchmarking*, *21*, 944-963. https://doi.org/10.1108/BIJ-09-2012-0064

Jüttner, U., Christopher, M., & Baker, S. (2007). Demand chain management-integrating marketing and supply chain management. *Industrial Marketing Management*, *36*(3), 377-392. https://doi.org/https://doi.org/10.1016/j.indmarman.2005.10.003

Kajüter, P., & Kulmala, H. I. (2005). Open-book accounting in networks: Potential achievements and reasons for failures. *Management Accounting Research*, *16*(2), 179-204.

Kaplan, R. (1984). The Evolution of Management Accounting. *The Accounting Review*, *LIX*, 390-418.

Kaplan, R., & Anderson, S. (2004). Time-Driven Activity-Based Costing. *Harvard business review*, *82*(11), 131-138. https://doi.org/10.2139/ssrn.485443

Kaplan, R., & Cooper, R. (1988). How Cost Accounting Distorts Product Costs. *Management Accounting*, *69*, 20-27.

Kaplan, R., & Norton, D. (1996). *The balanced scorecard: translating strategy into action*. Harvard business press.

Kaplan, R., Witkowski, M., Abbott, M., Guzman, A. B., Higgins, L., Meara, J., Padden, E., Shah, A., Waters, P., & Weidemeier, M. (2014). Using time-driven activity-based costing to identify value improvement opportunities in healthcare. *Journal of Healthcare Management*, *59*(6), 399-412.

Kembro, J. H., Norrman, A., & Eriksson, E. (2018). Adapting warehouse operations and design to omni-channel logistics: A literature review and research agenda. *International Journal of Physical Distribution and Logistics Management*, *48*(9), 890-912. https://doi.org/10.1108/IJPDLM-01-2017-0052

Kidd, A. (2005). *The Definition of Procurement* Procurement

Professional, https://silo.tips/download/the-definition-of-procurement

Kim, Y.-W., Han, S.-H., Yi, J.-S., & Chang, S. (2016). Supply chain cost model for prefabricated building material based on time-driven activity-based costing. *Canadian Journal of Civil Engineering*, *43*, 287-293. https://doi.org/10.1139/cjce-2015-0010

Kocaoğlu, B., Gülsün, B., & Tanyaş, M. (2013). A SCOR based approach for measuring a benchmarkable supply chain performance. *Journal of Intelligent Manufacturing*, *24*, 113-132.

Krauth, E., Moonen, H., & Popova, V. (2005). Understanding Performance Measurement and Control in Third Party Logistics. *Association for Information Systems AIS Electronic Library (AISeL)*, 157.

Kulmala, H. I. (2002). Open-book accounting in networks. *Liiketaloudellinen Aikakauskirja*, *2*, 157-180.

L Zimmerman, J. (2011). *Accounting for decision making and control*. McGraw-Hill/Irwin.

Labro, E., & Vanhoucke, M. (2008). Diversity in resource consumption patterns and robustness of costing systems to errors. *Management Science*, *54*(10), 1715-1730.

Lacy, P., & Rutqvist, J. (2015). *Waste to wealth: The circular economy advantage* (Vol. 91). Springer.

Lahutta, D., & Wroński, P. (2015). Customer Profitability Analysis with Time-Driven Activity-Based Costing: The Case Study of Polish Laboratory Diagnostics Market's Enterprise. *Managing Intellectual Capital and Innovation for Sustainable and Inclusive Society*, 455-465.

Lai, K. h., Ngai, E. W. T., & Cheng, T. C. E. (2002). Measures for evaluating supply chain performance in transport logistics. *Transportation Research Part E: Logistics and Transportation Review*, *38*, 439-456. https://doi.org/10.1016/S1366-5545(02)00019-4

Lambert, D. M., & Burduroglu, R. (2000). Measuring and selling the value of logistics. *The International Journal of Logistics Management*, *11*(1), 1-18.

Lambert, D. M., Cooper, M. C., & Pagh, J. D. (1998). Supply Chain Management: Implementation Issues and Research Opportunities. *The International Journal of Logistics Management*, *9*(2), 1-20. https://doi.org/10.1108/09574099810805807

Lavassani, K., Movahedi, B., & Kumar, V. (2008). Transition to B2B e-Marketplace Enabled Supply Chain: Readiness Assessment and Success Factors. CONF-IRM 2008 Proceedings,

Lawson, R. (2017). Working together to Enhance Supply Chain Management with Better Costing Practices. *APICS & IMA Report*.

Lee, C., Ching Yeung, Y., & Hong, Z. (2012). An integrated framework for outsourcing risk management. *Industrial Management & Data Systems*, *112*(4), 541-558.

Lemoine, W., & Dagnæs, L. (2003). Globalisation strategies and business organisation of a network of logistics service providers. *International Journal of Physical Distribution & Logistics Management*, *33*, 209-228. https://doi.org/10.1108/09600030310471961

Lere, J. C. (2000). Activity-based costing: A powerful tool for pricing. *Journal of Business and Industrial Marketing*, *15*, 23-33. https://doi.org/10.1108/08858620010311539

Lieb, R., & Bentz, B. A. (2005). The North American third party logistics industry in 2004: The provider CEO perspective. *International Journal of Physical Distribution and Logistics Management*, *35*(7/8), 595-611. https://doi.org/10.1108/09600030510623357

Lievens, Y., Van Den Bogaert, W., & Kesteloot, K. (2003). Activity-based costing: A practical model for cost calculation in radiotherapy. *International Journal of Radiation Oncology Biology Physics*, *57*, 522-535. https://doi.org/10.1016/S0360-3016(03)00579-0

Liu, C.-H., & Liu, H.-S. (2009). Increasing competitiveness of a firm and supply chain with web 2.0 initiatives. *International Journal of Electronic Business Management*, *7*(4), 248-255.

Liu, J., Quddoos, M. U., Akhtar, M. H., Amin, M. S., Tariq, M., & Lamar, A. (2022). Digital technologies and circular economy in supply chain management: In the era of COVID-19 pandemic. *Operations Management Research*, *15*(1-2), 326-341.

Lueg, R., & Morratz, H. (2017). Understanding the error-structure of Time-driven Activity-based Costing: A pilot implementation at a European manufacturing company. *European Journal of Management*, *17*(1), 49-56.

Lummus, R. R., & Vokurka, R. J. (1999). Defining supply chain management: A historical perspective and practical guidelines. *Industrial Management & Data Systems*, *99*, 11-17.

Ma, H. (2014). The Study of Cost Accounting in S Company Based On TDABC. *World Academy of Science, Engineering and Technology, International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*, *8*, 1715-1723.

Maria, M., Marchesini, P., Lúcia, R., & Alcântara, C. (2016). Logistics activities in supply chain business process A conceptual framework to guide their implementation. *The International Journal of Logistics Management*, *27*, 6-30. https://doi.org/10.1108/IJLM-04-2014-0068

Marzuki, S., Laksmono, B. S., & Subroto, A. (2020). Improving government's performance management by using the balanced scorecard on stakeholders perspectives. *Journal of the community development in Asia*, *3*(3), 29-47.

Matopoulos, A., & Papadopoulou, E.-M. (2010). *The Evolution of Logistics Service Providers and the Role of Internet-based Applications in Facilitating Global Operations*. Springer. https://doi.org/10.1007/978-1-84996-244-5_14

Matuszczak, A., & Chrąchol-Barczyk, U. (2016). Logistics customer service on the example of courier companies. *Marketing i Zarządzanie*, *46*, 57-65. https://doi.org/10.18276/miz.2016.46-06

Mentzer, J. T., Keebler, J. S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). defining supply chain management. *Journal of Business Logistics*, *22*(2), 1-25.

Mentzer, J. T., & Moon, M. A. (2004). *Sales forecasting management: a demand management approach*. Sage Publications.

Mentzer, J. T., Stank, T. P., & Esper, T. L. (2008). Supply chain management and its relationship to logistics, marketing, production, and operations management. *Journal of Business Logistics*, *29*, 31-46. https://doi.org/10.1002/j.2158-1592.2008.tb00067.x

Merriam, S. B. (2009). Qualitative Research: A Guide to Design and Implementation. Revised and Expanded from Qualitative Research and Case Study Application in Education. *Jossey-Bass*. https://doi.org/10.1017/CBO9781107415324.004

Miles, R. (2015). Complexity, representation and practice: Case study as method and methodology. Issues in Educational Research,

Miller, J. A. (1996). *Implementing activity-based management in daily operations*. John Wiley & Sons Incorporated.

Min, H., & Jong Joo, S. (2006). Benchmarking the operational efficiency of third party logistics providers using data envelopment analysis. *Supply chain management: An International journal*, *11*(3), 259-265.

Moroff, N. U., & Sardesai, S. (2019). Machine learning in demand planning: Cross-industry overview. Artificial Intelligence and Digital Transformation in Supply Chain Management: Innovative Approaches for Supply Chains. Proceedings of the Hamburg International Conference of Logistics (HICL), Vol. 27,

Muthimi, J., & Mwarora, A. (2023). Accomplishing Organizational Performance through Business Process Re-Engineering: Evidence from Selected Supermarkets in Mombasa City County, Kenya. *International Journal of Research and Innovation in Social Science*, *7*(6), 765-772.

Namazi, M. (2016). Time-driven activity-based costing: Theory, applications and limitations. *Iranian Journal of Management Studies*, *9*, 457-482A.

Neely, A., Kennerley, M., & Martinez, V. (2004). Does the balanced scorecard work: an empirical investigation. European Operations Management Association (EurOMA) International Conference, Fontainebleau, June,

No, J. J., & Kleiner, B. H. (1997). How to implement activity-based costing. *Logistics information management*, *10*(2), 68-72.

Oberhofer, P., & Dieplinger, M. (2014). Sustainability in the transport and logistics sector: Lacking environmental measures. *Business Strategy and the Environment*, *23*(4), 236-253.

Ochonogor, K. N., Osho, G. S., Anoka, C. O., & Dieli, O. J. (2022). The Impact of Supplier Base Consolidation on Procurement, Delivery, and Production Costs: Supply Chain Operations

Optimization and Vendor Consolidation. *International Research in Economics and Finance*, *6*(4), 10.
Öker, F., & Adigüzel, H. (2010). Time-driven activity-based costing: An implementation in a manufacturing company. *Journal of Corporate Accounting & Finance*, *22*(1), 75-92.
Onwuegbuzie, A. J., & Johnson, R. B. (2004). Mixed Methods Research: A Research Paradigm Whose Time Has Come. *Educational Researcher*, *33*, 14-26. https://doi.org/10.3102/0013189X033007014
Onwuegbuzie, A. J., & Leech, N. L. (2005). On Becoming a Pragmatic Researcher: The Importance of Combining Quantitative and Qualitative Research Methodologies. *International Journal of Social Research Methodology*, *8*, 375-387. https://doi.org/10.1080/13645570500402447
Pamucar, D., Chatterjee, K., & Zavadskas, E. K. (2019). Assessment of third-party logistics provider using multi-criteria decision-making approach based on interval rough numbers. *Computers and Industrial Engineering*, *127*, 383-407. https://doi.org/10.1016/j.cie.2018.10.023
Parker, C. (2000). Performance measurement. *Work Study*, *49*, 63-66. https://doi.org/10.1108/00438020010311197
Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice*. Sage publications.
Pavlić Skender, H., Mirković, P. A., & Prudky, I. (2017). The role of the 4PL model in a contemporary supply chain. *Pomorstvo*, *31*(2), 96-101.
Pedersen, S. G., Zachariassen, F., & Arlbjørn, J. S. (2012). Centralisation vs de-centralisation of warehousing: A small and medium-sized enterprise perspective. *Journal of Small Business and Enterprise Development*, *19*(2), 352-369. https://doi.org/10.1108/14626001211223946
Peris-Ortiz, M., García-Hurtado, D., & Devece, C. (2019). Influence of the balanced scorecard on the science and innovation performance of Latin American universities. *Knowledge Management Research & Practice*, *17*(4), 373-383.
Pinna, R., & Carrus, P. P. (2012). Reverse logistics and the role of fourth party logistics provider. In *Pathways to supply chain excellence* (pp. 91-114). https://shorturl.at/qrDUW
Pohlen, T. L., & La Londe, B. J. (1994). Implementing Activity-Based Costing (ABC) in Logistics. *Journal of Business Logistics*, *15*, 1-23. https://doi.org/http://dx.doi.org/10.1108/17506200710779521
Popat, K., Gracia, K. A., Guzman, A. B., & Feeley, T. W. (2018). Using time-driven activity-based costing to model the costs of various process-improvement strategies in acute pain management. *Journal of Healthcare Management*, *63*(4), e76-e85.
Qin, Y., & Liu, H. (2022). Application of value stream mapping in E-commerce: a case study on an Amazon retailer. *Sustainability*, *14*(2), 713.
Qureshi, M. N., & Kumar, P. (2008). An integrated model to identify and classify the key criteria and their role in the assessment of 3PL services providers. *Asia Pacific Journal of Marketing and Logistics*, *20*, 1355-5855. https://doi.org/10.1108/13555850810864579
Rajesh, R., Pugazhendhi, S., Ganesh, K., Ducq, Y., & Koh, S. C. L. (2012). Generic balanced scorecard framework for third party logistics service provider. *140*(1), 269-282. https://doi.org/10.1016/j.ijpe.2012.01.040
Reddy, K., Venter, H., & Olivier, M. S. (2012). Using time-driven activity-based costing to manage digital forensic readiness in large organisations. *Information Systems Frontiers*, *14*(5), 1061-1077.
Rogers, D. S., & Tibben-Lembke, R. (2001). An examination of reserve logistics practices *Journal of Business Logistics*, *22*, 129-148. https://doi.org/10.1002/j.2158-1592.2001.tb00007.x
Romano, P., & Formentini, M. (2012). Designing and implementing open book accounting in buyer–supplier dyads: A framework for supplier selection and motivation. *International Journal of Production Economics*, *137*(1), 68-83.
Rosic, H. (2012). *The economic and environmental sustainability of dual sourcing*. Peter Lang International Academic Publishers.

Rosinosky, G., Youcef, S., & Charoy, F. (2018). A genetic algorithm for cost-aware business processes execution in the cloud. Service-Oriented Computing: 16th International Conference, ICSOC 2018, Hangzhou, China, November 12-15, 2018, Proceedings 16,
Rouwenhorst, B., Reuter, B., Stockrahm, V., Van Houtum, G. J., Mantel, R. J., & Zijm, W. H. M. (2000). *Warehouse design and control: Framework and literature review* (Vol. 122). Elsevier Science B.V. https://doi.org/10.1016/S0377-2217(99)00020-X
Rowley, J. (2002). Using case studies in research. Management Research News,
Rudd, J. (2019). *A Practical Guide to Logistics: an introduction to transport, warehousing, trade and distribution*. Kogan Page.
Rushton, A., Croucher, P., & Baker, P. (2022). *The Handbook of Logistics and Distribution Management: Understanding the Supply Chain* (5th ed.). Kogan Page. https://books.google.com.sa/books?id=-jlUEAAAQBAJ
Ryu, K., & Sanchez, A. (2003). The Evaluation of Forecasting Methods at an Institutional Foodservice Dining Facility. *The Journal of Hospitality Financial Management*, *11*(1), 27-45. https://doi.org/10.1080/10913211.2003.10653769
Sanchez-Rodrigues, V., Potter, A., & Naim, M. M. (2010). Evaluating the causes of uncertainty in logistics operations. *The International Journal of Logistics Management*, *21* (1), 45-64. https://doi.org/https://doi.org/10.1108/09574091011042179
Santana, A., Afonso, P., & Rocha, A. (2014). Activity Based Costing and Time-Driven Activity Based Costing: Towards an Integrated Approach. Proceedings of the 2nd International Conference on Project Evaluation,
Sanyal, S. (2012, March 22, 2012). *A Brief History of Supply Chains - The Globalist*. https://www.theglobalist.com/a-brief-history-of-supply-chains/
Saunders, M., Lewis, P., & Thornhill, A. (2019). "Research Methods for Business Students" Chapter 4: Understanding research philosophy and approaches to theory development. *Research Methods for Business Students*, 128-171.
Scapens, R. W. (1991). *Management accounting: a review of contemporary developments* (2nd ed.). Palgrave HE UK. https://www.amazon.com/Management-Accounting-Review-Contemporary-Developments/dp/0333553535
Scapens, R. W., Ryan, B., & Theobald, M. (2002). *Research Methods and Methodology in Accounting and Finance* (2nd ed.). Thomson.
Schuhmacher, K., & Burkert, M. (2014). Traditional ABC and TimeDriven ABC: An Experimental Investigation. Management Accounting Section (MAS) Meeting,
Seal, W., Cullen, J., Dunlop, A., Berry, T., & Ahmed, M. (1999). Enacting a European supply chain: a case study on the role of management accounting. *Management Accounting Research*, *10*(3), 303-322.
Seuring, S., & Goldbach, M. (2002). *Cost Management in Supply Chains — Different Research Approaches* (illustrated ed.). Physica. https://books.google.com.pk/books/about/Cost_Management_in_Supply_Chains.html?id=8_7uCAAAQBAJ&redir_esc=y
Shank, J. K., & Govindarajan, V. (1993). *Strategic cost management: the new tool for competitive advantage*. Simon and Schuster.
Shields, M. D., & Young, S. M. (1989). A behavioral model for implementing cost management systems. *Journal of Cost Management*, *3*, 17-27.
Shmatko, A., Barykin, S., Sergeev, S., & Thirakulwanich, A. (2021). Modeling a logistics hub using the digital footprint method—the implication for open innovation engineering. *Journal of Open Innovation: Technology, Market, and Complexity*, *7*(1), 59.
Siguenza-Guzman, L., Auquilla, A., Van den Abbeele, A., & Cattrysse, D. (2016). Using time-driven activity-based costing to identify best practices in academic libraries. *The Journal of Academic Librarianship*, *42*(3), 232-246.

Silva, T. F., Gonçalves, A. T., & Leite, M. S. (2014). Logistics cost management: insights on tools and operations. *International Journal of Logistics Systems and Management*, *19*(3), 329-346.
Sink, H., & Langley, C.-J. (1997). a Managerial Framework for the Acquisition of Third-Party Logistics Services. *Journal of Business Logistics*, *18*, 163-189.
Smith, M., & Dikolli, S. (1995). Customer profitability analysis: an activity-based costingapproach. *Managerial Auditing Journal*, *10*(7), 3-7.
Soinio, J., Tanskanen, K., & Finne, M. (2012). How logistics-service providers can develop value-added services for SMEs: A dyadic perspective. *International Journal of Logistics Management*, *23*(1), 31-49. https://doi.org/https://doi.org/10.1108/09574091211226911
Somapa, S., Cools, M., & Dullaert, W. (2012). Unlocking the potential of time-driven activity-based costing for small logistics companies. *International Journal of Logistics Research and Applications*, *15*(5), 303-322. https://doi.org/10.1080/13675567.2012.742043
Speranza, M. G. (2018). Trends in transportation and logistics. *European Journal of Operational Research*, *264*(3), 830-836.
Srivastava, S. K. (2008). Network design for reverse logistics. *Omega*, *36*(4), 535-548.
Staff), M. H. L. M. L. (2004, July 1, 2004). *CLM Changes Name*. Material Handling & Logistics. https://www.mhlnews.com/archive/article/22045780/clm-changes-name
Stake, R. (1995). The Art of Case Study Research. *Thousand Oaks, CA: Sage*, 49-68. https://doi.org/10.1108/eb024859
Starman, A. B. (2013). The case study as a type of qualitative research. *Journal of Contemporary Educational Studies 64*, 28-43. https://doi.org/10.1097/00005217-199512030-00003
Staudt, F. H., Alpan, G., Di Mascolo, M., & Rodriguez, C. M. T. (2015). Warehouse performance measurement: a literature review. *International Journal of Production Research*, *53*, 5524-5544. https://doi.org/10.1080/00207543.2015.1030466
Stephen, M., & Meyers, F. E. (2019). *Manufacturing facilities design and material handling* (FIFTH ed.). Purdue University Press.
Stewart, G. (1997). Supply-chain operations reference model (SCOR): the first cross-industry framework for integrated supply-chain management. *Logistics information management*, *10*(2), 62-67.
Stout, D. E., & Propri, J. M. (2011). Implementing Time-Driven Activity-Based Costing at a Medium-Sized Electronics Company. *Management Accounting Quartertly*, *12*, 1-11.
Sundarakani, B., Tan, A., & Koźlak, A. (2012). Determinants of fifth party logistics (5PL): Service providers for supply chain management. *International Journal of Logistics Systems and Management*, *13*(3), 287-316. https://doi.org/10.1504/IJLSM.2012.049700
Sutton-Brady, C., & Spencer, R. (2022). Guest editorial: Interactions, relationships and networks in a digital era. *Journal of Business & Industrial Marketing*, *37*(11), 2141-2141.
Swenson, D. (1995). The Benefits of Activity-Based Cost Management to the Manufacturing Industry. *Journal of Management Accounting Research*, *7*, 1-6.
Taticchi, P., Tonelli, F., & Cagnazzo, L. (2010). Performance measurement and management: a literature review and a research agenda. *Measuring Business Excellence*, *14*, 4-18. https://doi.org/10.1108/13683041011027418
Tseng, Y.-Y., Long, W., & Taylor, M. A. P. (2005). The role of transportation in logistics chain. *Proceedings of the Eastern Asia Society for Transportation Studies*, *5*, 1657-1672.
van der Westhuizen, C., & Niemann, W. (2022). Strategic supply chain alignment: The role of third-party logistics service providers during disruption recovery. *Journal of Transport and Supply Chain Management*, *16*, 738.
Van Raaij, E. M. (2005). The strategic value of customer profitability analysis. *Marketing Intelligence & Planning*, *23*(4), 372-381. https://doi.org/10.1108/02634500510603474
Vanwynsberghe, R., & Khan, S. (2007). Redefining Case Study. *6*(2), 80-94.
Varadejsatitwong, P., Banomyong, R., & Julagasigorn, P. (2021). Developing a performance measurement framework for logistics service providers. Proceedings of the 2021

Conference: The International Conference on Industrial Engineering and Operations Management (IEOM), Monterrey, Mexico,

Varila, M., Seppänen, M., & Suomala, P. (2007). Detailed cost modelling: a case study in warehouse logistics. *International Journal of Physical Distribution & Logistics Management*, *37*, 184-200. https://doi.org/10.1108/09600030710742416

Vasiliauskas, A. V., & Barysienė, J. (2008). Review of current state of European 3PL market and its main challenges. *Computer Modelling and New Technologies*, *12*(2), 17-21.

Vercio, A. (2008). Full absorption: The good, the bad, and the ugly. *Journal of Corporate Accounting & Finance*, *19*(3), 51-55.

Wegmann, G. (2010). Compared activity-based costing case studies in the information system departments of two groups in France: A strategic management accounting approach. *Proceedings of Business and Information*, *7*, 5-7.

Wild, T. (2017). *Best practice in inventory management* (3rd ed.). Routledge. https://doi.org/10.4324/9781315231532

Wu, X.-d., Wang, Y.-f., Yue, D.-m., & Sun, Z.-j. (2011). Modeling and Error Analysis of Time-driven Activity-based Costing. 2011 IEEE 18th International Conference on Industrial Engineering and Engineering Management,

Xiao, S., Sun, Y., & Shi, S. (2009). Study on modern logistics cost management. 2009 16th International Conference on Industrial Engineering and Engineering Management,

Yan, R. (2019). Innovation Strategies on Cost Management for Third Party Logistics Enterprises. *179*, 565-570. https://doi.org/10.2991/ieesasm-17.2018.119

Yeung, A. C. (2006). The impact of third-party logistics performance on the logistics and export performance of users: an empirical study. *Maritime Economics & Logistics*, *8*, 121-139.

Yin, R. K. (2003). *Case Study Research: Design and Methods* (illustrated ed.). SAGE.

Yin, R. K. (2014). *Case study research: Design and methods (5th ed.)*. Thousand Oaks, CA: SAGE Publications.

Yin, R. K. (2018). Case Study Research and Applications. Case Study Research and Applications: Design and Methods,

Zamrud, N., & Abu, M. (2020). Comparative study: activity based costing and time driven activity based costing in electronic industry. *Journal of Modern Manufacturing Systems and Technology*, *4*(1), 68-81.

Zhang, X., & Yi, H. (2008). The analysis of logistics cost based on time-driven ABC and TOC. 2008 IEEE International Conference on Service Operations and Logistics, and Informatics,

Zimmerman, J. L. (2001). Conjectures regarding empirical managerial accounting research. *Journal of accounting and economics*, *32*(1-3), 411-427.

Appendix A

CONSENT FORM FOR PARTICIPANTS INVOLVED IN THE RESEARCH – G1: General manager

INFORMATION TO PARTICIPANTS:

We would like to invite you to be a part of a study into THE ROLE OF THE TIME-DRIVEN ACTIVITY-BASED COSTING MODEL IN THE THIRD-PARTY LOGISTICS

This research aims to understand the role of the time-driven activity-based costing model in the third-party logistics industry. More specifically, it aims to explore how the cost information of the integrated logistics services will be modelled under the time-driven activity-based costing approach comparing with the cost information generated by the traditional activity-based costing model in the case of a third-party logistics company. Furthermore, it aims to understand how the time-driven activity-based costing model can help in improving the efficiency of third-party logistics by reducing the logistics costs and enhancing the profitability.

CERTIFICATION BY PARTICIPANT

I, of

certify that I am at least 18 years old* and that I am voluntarily giving my consent to participate in the study titled: THE ROLE OF THE TIME-DRIVEN ACTIVITY-BASED COSTING MODEL IN THE THIRD-PARTY LOGISTICS being conducted at Victoria University by: KHALID HUSSAIN ALAHMARI (s4578872)

I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by:

KHALID HUSSAIN ALAHMARI (s4578872)

and that I freely consent to participation involving the below mentioned procedures:

- Recorded interviews with the researcher (audio recording)
- Answering the researcher’s questions in the scope of the research requirements (refer to “Information to Participants Involved in Research”)

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be recorded and transcribed for the research's analysis purposes, and it will be kept confidential.

Signed: Date:

CONSENT FORM FOR PARTICIPANTS INVOLVED IN THE RESEARCH – G2: departments' managers

INFORMATION TO PARTICIPANTS:

We would like to invite you to be a part of a study into THE ROLE OF THE TIME-DRIVEN ACTIVITY-BASED COSTING MODEL IN THE THIRD-PARTY LOGISTICS

This research aims to understand the role of the time-driven activity-based costing model in the third-party logistics industry. More specifically, it aims to explore how the cost information of the integrated logistics services will be modelled under the time-driven activity-based costing approach comparing with the cost information generated by the traditional activity-based costing model in the case of a third-party logistics company. Furthermore, it aims to understand how the time-driven activity-based costing model can help in improving the efficiency of third-party logistics by reducing the logistics costs and enhancing the profitability.

CERTIFICATION BY PARTICIPANT

I,

of

certify that I am at least 18 years old* and that I am voluntarily giving my consent to participate in the study titled:

THE ROLE OF THE TIME-DRIVEN ACTIVITY-BASED COSTING MODEL IN THE THIRD-PARTY LOGISTICS

being conducted at Victoria University by: KHALID HUSSAIN ALAHMARI (s4578872)

I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by:

KHALID HUSSAIN ALAHMARI (s4578872)

and that I freely consent to participation involving the below mentioned procedures:

- Recorded interviews with the researcher (audio recording)
- Answering the researcher's questions in the scope of the research requirements (refer to "Information to Participants Involved in Research")

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be recorded and transcribed for the research's analysis purposes, and it will be kept confidential.

Signed: Date:

CONSENT FORM FOR PARTICIPANTS INVOLVED IN THE RESEARCH – G3: Operation team

INFORMATION TO PARTICIPANTS:

We would like to invite you to be a part of a study into THE ROLE OF THE TIME-DRIVEN ACTIVITY-BASED COSTING MODEL IN THE THIRD-PARTY LOGISTICS

This research aims to understand the role of the time-driven activity-based costing model in the third-party logistics industry. More specifically, it aims to explore how the cost information of the integrated logistics services will be modelled under the time-driven activity-based costing approach comparing with the cost information generated by the traditional activity-based costing model in the case of a third-party logistics company. Furthermore, it aims to understand how the time-driven activity-based costing model can help in improving the efficiency of third-party logistics by reducing the logistics costs and enhancing the profitability.

CERTIFICATION BY PARTICIPANT

I,

of

certify that I am at least 18 years old* and that I am voluntarily giving my consent to participate in the study titled:

THE ROLE OF THE TIME-DRIVEN ACTIVITY-BASED COSTING MODEL IN THE THIRD-PARTY LOGISTICS

being conducted at Victoria University by: KHALID HUSSAIN ALAHMARI (s4578872)

I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by:

KHALID HUSSAIN ALAHMARI (s4578872)

and that I freely consent to participation involving the below mentioned procedures:

- Interactions with the researcher during the observation sessions
- Answering the researcher's questions in the scope of the research requirements (refer to "Information to Participants Involved in Research")

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be written down for the research's analysis purposes, and it will be kept confidential.

Signed: Date:

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email Researchethics@vu.edu.au or phone (03) 9919 4781 or 4461. Or, you can contact the research's primary Chief Investigator: Prof. Sophia Everett, Email: Sophia.Everett@vu.edu.au, Phone: +61 0418678755.

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH – G1: General Manager

You are invited to participate

You are invited to participate in a research project entitled **The Role of the Time-Driven Activity-Based Costing Model in the Third-Party Logistics**.

This project is being conducted by a student researcher **Khalid Alahmari** as part of his PhD study at Victoria University under the supervision of **Prof. Sophia Everett** and **Dr. Pari Sima Nassirina** from the **School of Business**.

Project explanation

This research aims to understand the role of the time-driven activity-based costing model in the third-party logistics industry. More specifically, it aims to explore how the cost information of the integrated logistics services will be modelled under the time-driven activity-based costing approach comparing with the cost information generated by the traditional activity-based costing model in a case third-party logistics company. Mainly, the research seeks to compare the customers and services profitability under both time-driven activity-based costing and activity-based costing systems. Furthermore, it aims to understand how the time-driven activity-based costing model can help in improving the efficiency of the third-party logistics by reducing the logistics costs and enhancing the profitability.

What will I be asked to do?

This research aims to understand the processes of the logistics operation in order to develop an ideal costing model accordingly. Therefore, the participants will interviewed about the business model, history, financial and operational performance, and customers. In addition, the researcher will ask about the existing costing model' outcomes, mechanism, advantages and disadvantages, and other related questions. These interviews will be recorded (audio recording) and the audio content will be transcribed for the research analysis purposes. The researcher may need to access confidential data such as financial statements, costs, customers records, and the orders history. This information will be securely stored and disguised in the research's outcomes.

What will I gain from participating?

The case company will receive a well-developed report on both existing and newly developed costing systems upon the completion of the research. This report will provide management with more accurate information about the customers and services profitability and cost. In addition, this research will provide the management with some efficiency-improvement opportunities that will be discovered and outlined by the new costing model. Each department of the company will obtain the research findings that pertain to it, such as the department's accurate costs according to the methodology of time-driven activity-based costing model, the costs of unused resources within the department, as well as some recommendations on how to improve the department's efficiency.

How will the information I give be used?

The information that you provide will be used for the research's analysis purposes that are needed to meet the research's aims. The interviews records (both audio and transcripts) will be given unique IDs so that the researcher can keep the personal information of participants safe and secured. The confidential data will be accessed and transferred with the permission and supervision of the company's management using a secured tool such as USB flash driver. The researcher will not take any hard copies outside the location. All documents will be exported in digital format (if possible), or they will be scanned and stored in the university's storage cloud system "R-drive", which will be monitored by the institution and investigators. An appropriate and secured disposal method will be employed by the research's Chief Investigator, Prof. Sophia Everett. The findings of this research will not explicitly show your confidential data as they will be disguised in the research's outcomes.

What are the potential risks of participating in this project?

Due to the current pandemic circumstances, this research is considered high-risk research as it involves field study and physical engagement with participants. Therefore, the researcher and participants should consider some factors to mitigate the risk. The researcher and participants must be physically distanced as much as possible in their meetings. In addition, they must follow the local health guidance and arrangements.(For example, wearing a mask should occur). In terms of the risk of giving confidential information to the researcher, the researcher will not keep physical records at all. Instead, he will record all information digitally at the university's storage system. Names (including the company's name), numbers, and all other information will be protected in the research's outcomes. The participation in this research is voluntary. There is no adverse consequences associated with your rejection or withdrawal from participation at any time. The company's management will not have access to your answers. However, they will have access to the research's findings, which will not disclose real numbers or names. Other than these aforementioned risks, there is no risk associated with participation in this research except the normal level of inconvenience.

How will this project be conducted?

A case-study methodology will be adopted, and the researcher will spend up to 3 months in your company collecting data by observing the operation teams, interviewing managers, and reviewing the history of orders and customers, and accessing the internal information system to study the existing costing system. For interviews, the researcher expects one or two interviews with every department's manager (or assistant manager) in person. The interview will last for 45-60 minutes each. After the interview, the researcher will ask you for a short tour inside the department to view and record some details of the department such as the space layout, number of offices, employees, etc. The researcher expects that he will spend between 5 to10 business days in each department to capture the data needed for this research.

Who is conducting the study?

Victoria University, Melbourne, Australia.

Professor Sophia Everett, Mobile: 0418 678 755, Email: sophia.everett@vu.edu.au

Khalid Hussain Alahmari, Mob: +966533883393 /+61452005778, Email: khalid.alahmari@live.vu.edu.au

Any queries about your participation in this project may be directed to the Chief Investigator listed above.

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH – G2 (Departments' heads)

You are invited to participate

You are invited to participate in a research project entitled **The Role of the Time-Driven Activity-Based Costing Model in the Third-Party Logistics**.

This project is being conducted by a student researcher **Khalid Alahmari** as part of his PhD study at Victoria University under the supervision of **Prof. Sophia Everett** and **Dr. Pari Sima Nassirina** from the **School of Business**.

Project explanation

This research aims to understand the role of the time-driven activity-based costing model in the third-party logistics industry. More specifically, it aims to explore how the cost information of the integrated logistics services will be modelled under the time-driven activity-based costing approach comparing with the cost information generated by the traditional activity-based costing model in a case third-party logistics company.

Mainly, the research seeks to compare the customers and services profitability under both time-driven activity-based costing and activity-based costing systems. Furthermore, it aims to understand how the time-driven activity-based costing model can help in improving the efficiency of the third-party logistics by reducing the logistics costs and enhancing profitability.

What will I be asked to do?

The participants will be interviewed about their departments' roles in the overall business' operation, the activities that are being implemented, resources available in their departments, and about the existing costing system. Such information will be used for the analysis purposes and for the new costing model development. The interviews will be recorded (audio recording) and the audio content will be transcribed for the research analysis purposes. The researcher may need to access confidential data such as financial reports, cost details, customers records, and the orders history with the permission of the company's management.

What will I gain from participating?

The case company will receive a well-developed report on both existing and newly developed costing systems upon the completion of the research. This report will provide management with more accurate information about the customers and services profitability and cost. In addition, this research will provide the management with some efficiency-improvement opportunities that will be discovered and outlined by the new costing model. Each department of the company will obtain the research findings that pertain to it, such as the department's accurate costs according to the methodology of time-driven activity-based costing model, the costs of unused resources within the department, as well as some recommendations on how to improve the department's efficiency.

How will the information I give be used?

The information that you provide will be used for the research's analysis purposes that are needed to meet the research's aims. The interviews records (both audio and transcripts) will be given unique IDs so that the researcher can keep the personal information of participants safe and secured. The confidential data will be accessed and transferred with the permission and supervision of the company's management using a secured tool such as USB flash driver. The researcher will not take any hard copies outside the location. All documents will be exported in digital format (if possible), or they will be scanned and stored in the university's storage cloud system "R-drive", which will be monitored by the institution and investigators. An appropriate and secured disposal method will be employed by the research's Chief Investigator, Prof. Sophia Everett. The findings of this research will not explicitly show your confidential data as they will be disguised in the research's outcomes.

What are the potential risks of participating in this project?

Due to the current pandemic circumstances, this research is considered high-risk research as it involves field study and physical engagement with participants. Therefore, the researcher and participants should consider some factors to mitigate the risk. The researcher and participants must be physically distanced as much as possible in their meetings. In addition, they must follow the health guidance and arrangements (For example, wearing a mask should occur.) In terms of the risk of giving confidential information to the researcher, the researcher will not keep physical records at all. Instead, he will record all information digitally at the university's storage system. Names (including the company's name), numbers, and all other information will be protected in the research's outcomes. The participation in this research is voluntary. There is no adverse consequences associated with your rejection or withdrawal from participation at any time. The company's management will not have access to your answers. However, they will have access to the research's findings, which will not disclose real numbers or names. Other than these aforementioned risks, there is no risk associated with participation in this research except the normal level of inconvenience.

How will this project be conducted?

A case-study methodology will be adopted, and the researcher will spend up to 3 months in your company collecting data by observing the operation teams, interviewing managers, and reviewing the history of orders and customers, and accessing the internal information system to study the existing costing system. For interviews, the researcher expects one or two interviews with every department's manager (or assistant manager) in person. The interview will last for 45-60 minutes each. After the interview, the researcher will ask you for a short tour inside the department to view and record some details of the department such as the space layout, number of offices, employees, etc. The researcher expects that he will spend between 5 to- 10 business days in each department to capture the data needed for this research.

Who is conducting the study?

Victoria University, Melbourne, Australia.

Chief Investigator: Professor Sophia Everett, Mobile: 0418 678 755, Email: sophia.everett@vu.edu.au

Student: Khalid Hussain Alahmari, Mob: +966533883393 /+61452005778, Email: khalid.alahmari@live.vu.edu.au

Any queries about your participation in this project may be directed to the Chief Investigator listed above.

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH – G3: Operation team

You are invited to participate

You are invited to participate in a research project entitled **The Role of the Time-Driven Activity-Based Costing Model in the Third-Party Logistics**.

This project is being conducted by a student researcher **Khalid Alahmari** as part of his PhD study at Victoria University under the supervision of **Prof. Sophia Everett** and **Dr. Pari Sima Nassirina** from the **School of Business**.

Project explanation

This research aims to understand the role of the time-driven activity-based costing model in the third-party logistics industry. More specifically, it aims to explore how the cost information of the integrated logistics services will be modelled under the time-driven activity-based costing approach comparing with the cost information generated by the traditional activity-based costing model in a case third-party logistics company. Mainly, the research seeks to compare the customers and services profitability under both time-driven activity-based costing and activity-based costing systems. Furthermore, it aims to understand how the time-driven activity-based costing model can help in improving the efficiency of the third-party logistics by reducing the logistics costs and enhancing the profitability.

What will I be asked to do?

This research aims to understand the processes of the logistics operation in order to develop an ideal costing model accordingly. Therefore, the participants will be observed during the research period (up to 3 months) in order to understand the operation processes, activities, durations, variations, and efficiency-improvement opportunities. The researcher will interact with participants during their work times to obtain clarification or explanation for any part of the operation process. The interaction's outcomes will be written down in the researcher's notes for the research's analysis purposes.

What will I gain from participating?

The case company will receive a well-developed report on both existing and newly developed costing systems upon the completion of the research. This report will provide management with more accurate information about the customers and services profitability and cost. In addition, this research will provide the management with some efficiency-improvement opportunities that will be discovered and outlined by the new costing model. Each department of the company will obtain the research findings that pertain to it, such as the department's accurate costs according to the methodology of time-driven activity-based costing model, the costs of unused resources within the department, as well as some recommendations on how to improve the department's efficiency.

How will the information I give be used?

The information that you provide will be used for the research's analysis purposes that are needed to meet the research's aims only. The researcher will not share your personal details with any party either inside or outside your organisation. The activities details such as steps and durations will be observed and recorded to design the new costing model, and they will not be used for any other purpose. Data you'll provide will not be shared with your manager and they will not be used as a performance evaluation means. The raw data will be securely stored during and after the project. An appropriate and secured disposal method will be employed by the research's Chief Investigator, Prof. Sophia Everett. The findings of this research will not explicitly show your confidential data as they will be disguised in the research's outcomes.

What are the potential risks of participating in this project?

Due to the current pandemic circumstances, this research is considered high-risk research as it involves field study and physical engagement with participants. Therefore, the researcher and participants should consider some factors to mitigate the risk. The researcher and participants must be physically distanced as much as possible in their meetings. In addition, they must follow the health guidance and arrangements (For example, wearing a mask should occur.) In terms of the risk of giving confidential information to the researcher, the researcher will not keep physical records at all. Instead, he will record all information digitally at the university's storage system. Names (including the company's name), numbers, and all other information will be protected in the research's outcomes. The participation in this research is voluntary. There is no adverse consequences associated with your rejection or withdrawal from participation at any time. The company's management will not have access to your answers. However, they will have access to the research's findings, which will not disclose real numbers or names. Other than these aforementioned risks, there is no risk associated with participation in this research except the normal level of inconvenience.

How will this project be conducted?

A case-study methodology will be adopted, and the researcher will spend up to 3 months in your company collecting data by observing the operation, interviewing some staff, and reviewing the history of orders and customers, and accessing the internal information system to study the existing costing system. For observation sessions, the researcher expects that he will spend between 5 to-10 business days in each department to understand its activities, durations, resources, and other needed information. The researcher will interact with participants for a few days during the research period asking them about their actions and the logic behind. Also, he will record his notes to build the costing model based on.

Who is conducting the study?

Victoria University, Melbourne, Australia.

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Any queries about your participation in this project may be directed to the Chief Investigator listed above.

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

Appendix B

1. Developing the TD-ABC model

Step two: Resource pools

RP	Description	January (SAR)	February (SAR)	March (SAR)	Total (SAR)
DMM-DR	Dammam_Driver	90972	86446	82262	259680
DMM-LB	Dammam_Labour	373774.4	380930.29	379995.42	1134700.11
DMM-TR	Dammam_Truck	228789.72	234171.25	205242.96	668203.93
DMM-WH-A	Dammam_Warehouse_Ambient	128027.6332	119728.9973	139967.1866	387723.8172
DMM-WH-C	Dammam_Warehouse_Chilled	133135.3027	123095.4643	146677.4056	402908.1727
DMM-WH-E	Dammam_Warehouse_External	135029.4801	123787.3976	122556.5057	381373.3834
DMM-WH-F	Dammam_Warehouse _Frozen	333646.3239	292259.6308	357759.552	983665.5068
HED-AC	Headoffice_Accounts	16888	16887	16887	50662
HED-MG	Headoffice_Management	317684.19	318994.24	339193.28	975871.71
HED-MN	Headoffice_Maintenance	17948	17948	17948	53844
HED-SC	Headoffice_Supply chain	6477	7027	6991	20495
JED-DR	Jeddah_Driver	19759	19595	19400	58754
JED-LB	Jeddah_Labour	190538.12	167955.8	174974.43	533468.35
JED-TR	Jeddah_Truck	142315.08	139001.73	141050.89	422367.7
JED-WH-A	Jeddah_Warehouse_Ambient	76903.29139	74028.27085	88841.59717	239773.1594
JED-WH-C	Jeddah_Warehouse_Chilled	47158.07379	48205.10353	52404.50115	147767.6785
JED-WH-F	Jeddah_Warehouse _Frozen	27013.70482	38246.37563	38867.10168	104127.1821
RYD-DR	Riyadh_Driver	11321	9482	10048	30851
RYD-LB	Riyadh_Labour	110775.35	105160.49	109460.12	325395.96
RYD-TR	Riyadh_Truck	134376.52	125881.93	125669.04	385927.49
RYD-WH-A	Riyadh_Warehouse_Ambient	18665.37444	22977.45819	20660.51248	62303.3451
RYD-WH-C	Riyadh_Warehouse_Chilled	20429.49832	25873.2093	22948.25216	69250.95978
RYD-WH-E	Riyadh_Warehouse_External	65955.58183	67906.41292	64988.91359	198850.9083
RYD-WH-F	Riyadh_Warehouse _Frozen	57634.45542	73363.41959	65202.61177	196200.4868
Grand Total		**-2,705,217.10**	**-2,634,952.47**	**-2,745,996.28**	**-8,094,165.85**

Table 1: Resource pools expenses in Q1-2021

Step three: The practical capacity

January 2021:

Resource Pool	Capacity	Resource Driver	Resource Pool	Capacity	Resource Driver
DMM-WH-F	6074	Pallet	DMM-TR	30	Trucks
DMM-WH-C	2652	Pallet	RYD-TR	27	Trucks
DMM-WH-A	2292	Pallet	JED-TR	17	Trucks
DMM-WH-E	4998	Pallet	DMM-LB	39	FTEs - Labour
RYD-WH-F	1488	Pallet	RYD-LB	11	FTEs - Labour
RYD-WH-C	515	Pallet	JED-LB	14	FTEs - Labour
RYD-WH-A	408	Pallet	DMM-DR	32	FTEs - Labour
RYD-WH-E	1884	Pallet	RYD-DR	27	FTEs - Labour
JED-WH-F	564	Pallet	JED-DR	17	FTEs - Labour
JED-WH-C	1340	Pallet	HED-AC	2	FTEs - Employee
JED-WH-A	2116	Pallet	HED-SC	1	FTEs - Labour

Table 2: Resource pools capacity in January 2021

Resource Pool	Practical capacity	Capacity unit	Resource Pool	Practical capacity	Capacity unit
DMM-WH-F	7531.76	CBM	DMM-TR	283200	km
DMM-WH-C	3288.48	CBM	RYD-TR	254880	km
DMM-WH-A	2842.08	CBM	JED-TR	160480	km
DMM-WH-E	6197.52	CBM	DMM-LB	434122	min
RYD-WH-F	1845.12	CBM	RYD-LB	122445	min
RYD-WH-C	638.6	CBM	JED-LB	155839	min
RYD-WH-A	505.92	CBM	DMM-DR	356203	min
RYD-WH-E	2336.16	CBM	RYD-DR	300546	min
JED-WH-F	699.36	CBM	JED-DR	189233	min
JED-WH-C	1661.6	CBM	HED-AC	19420	min
JED-WH-A	2623.84	CBM	HED-SC	11,131.5	min

Table 3: Resource pool practical capacity in January 2021

February 2021:

Resource Pool	Capacity	Resource Driver	Resource Pool	Capacity	Resource Driver
DMM-WH-F	6074	Pallet	DMM-TR	30	Trucks
DMM-WH-C	2652	Pallet	RYD-TR	27	Trucks

DMM-WH-A	2292	Pallet	JED-TR	17	Trucks
DMM-WH-E	4998	Pallet	DMM-LB	39	FTEs - Labour
RYD-WH-F	1488	Pallet	RYD-LB	15	FTEs - Labour
RYD-WH-C	515	Pallet	JED-LB	13	FTEs - Labour
RYD-WH-A	408	Pallet	DMM-DR	32	FTEs - Labour
RYD-WH-E	1884	Pallet	RYD-DR	27	FTEs - Labour
JED-WH-F	564	Pallet	JED-DR	17	FTEs - Labour
JED-WH-C	1340	Pallet	HED-AC	2	FTEs - Employee
JED-WH-A	2116	Pallet	HED-SC	1	FTEs - Labour

Table 4: Resource pools capacity in February 2021

Resource Pool	Practical capacity	Capacity unit	Resource Pool	Practical capacity	Capacity unit
DMM-WH-F	7531.76	CBM	DMM-TR	283200	km
DMM-WH-C	3288.48	CBM	RYD-TR	254880	km
DMM-WH-A	2842.08	CBM	JED-TR	160480	km
DMM-WH-E	6197.52	CBM	DMM-LB	434122	min
RYD-WH-F	1845.12	CBM	RYD-LB	166970	min
RYD-WH-C	638.6	CBM	JED-LB	144707	min
RYD-WH-A	505.92	CBM	DMM-DR	356203	min
RYD-WH-E	2336.16	CBM	RYD-DR	300546	min
JED-WH-F	699.36	CBM	JED-DR	189233	min
JED-WH-C	1661.6	CBM	HED-AC	19420	min
JED-WH-A	2623.84	CBM	HED-SC	11131.5	min

Table 5: Resource pools practical capacity in February 2021

March 2021:

Resource Pool	Capacity	Resource Driver	Resource Pool	Capacity	Resource Driver
DMM-WH-F	6074	Pallet	DMM-TR	30	Trucks
DMM-WH-C	2652	Pallet	RYD-TR	27	Trucks
DMM-WH-A	2292	Pallet	JED-TR	17	Trucks
DMM-WH-E	4998	Pallet	DMM-LB	39	FTEs - Labour
RYD-WH-F	1488	Pallet	RYD-LB	11	FTEs - Labour
RYD-WH-C	515	Pallet	JED-LB	14	FTEs - Labour
RYD-WH-A	408	Pallet	DMM-DR	32	FTEs - Labour
RYD-WH-E	1884	Pallet	RYD-DR	27	FTEs - Labor

JED-WH-F	564	Pallet	JED-DR	17	FTEs - Labor
JED-WH-C	1340	Pallet	HED-AC	2	FTEs - Employee
JED-WH-A	2116	Pallet	HED-SC	1	FTEs - Labor

Table 6: Resource pools capacity in March 2021

Resource Pool	Practical capacity	Capacity unit	Resource Pool	Practical capacity	Capacity unit
DMM-WH-F	7531.76	CBM	DMM-TR	283200	km
DMM-WH-C	3288.48	CBM	RYD-TR	254880	km
DMM-WH-A	2842.08	CBM	JED-TR	160480	km
DMM-WH-E	6197.52	CBM	DMM-LB	434122	min
RYD-WH-F	1845.12	CBM	RYD-LB	122445	min
RYD-WH-C	638.6	CBM	JED-LB	155839	min
RYD-WH-A	505.92	CBM	DMM-DR	356203	min
RYD-WH-E	2336.16	CBM	RYD-DR	300546	min
JED-WH-F	699.36	CBM	JED-DR	189233	min
JED-WH-C	1661.6	CBM	HED-AC	19420	min
JED-WH-A	2623.84	CBM	HED-SC	11131.5	min

Table 7: Resource pool practical capacity in March 2021

Step four: Capacity cost rates (CCRs) calculations

January 2021:

	CCR in SAR per CBM			
Resource Pool	For 1 month	For 1 day	Resource Pool	CCR in SAR per min
DMM-WH-F	44.3	1.4	DMM-TR	0.81
DMM-WH-C	40.5	1.3	RYD-TR	0.53
DMM-WH-A	45.0	1.5	JED-TR	0.89
DMM-WH-E	21.8	0.7	DMM-LB	0.86
RYD-WH-F	31.2	1.0	RYD-LB	0.90
RYD-WH-C	32.0	1.0	JED-LB	1.22
RYD-WH-A	36.9	1.2	DMM-DR	0.26
RYD-WH-E	28.2	0.9	RYD-DR	0.04
JED-WH-F	38.6	1.2	JED-DR	0.10
JED-WH-C	28.4	0.9	HED-AC	0.87
JED-WH-A	29.3	0.9	HED-SC	0.58

Table 8: The CCR per each resource pool in January 2021

February 2021:

Resource Pool	CCR in SAR per CBM For 1 month	CCR in SAR per CBM For 1 day	Resource Pool	CCR in SAR per min
DMM-WH-F	38.8	1.4	DMM-TR	0.83
DMM-WH-C	37.4	1.3	RYD-TR	0.49
DMM-WH-A	42.1	1.5	JED-TR	0.87
DMM-WH-E	20.0	0.7	DMM-LB	0.88
RYD-WH-F	39.8	1.4	RYD-LB	0.63
RYD-WH-C	40.5	1.4	JED-LB	1.16
RYD-WH-A	45.4	1.6	DMM-DR	0.24
RYD-WH-E	29.1	1.0	RYD-DR	0.03
JED-WH-F	54.7	2.0	JED-DR	0.10
JED-WH-C	29.0	1.0	HED-AC	0.87
JED-WH-A	28.2	1.0	HED-SC	0.63

Table 9: The CCR per each resource pool in February 2021

March 2021:

Resource Pool	CCR in SAR per CBM For 1 month	CCR in SAR per CBM For 1 day	Resource Pool	CCR in SAR per min
DMM-WH-F	47.5	1.5	DMM-TR	0.72
DMM-WH-C	44.6	1.4	RYD-TR	0.49
DMM-WH-A	49.2	1.6	JED-TR	0.88
DMM-WH-E	19.8	0.6	DMM-LB	0.88
RYD-WH-F	35.3	1.1	RYD-LB	0.89
RYD-WH-C	35.9	1.2	JED-LB	1.12
RYD-WH-A	40.8	1.3	DMM-DR	0.23
RYD-WH-E	27.8	0.9	RYD-DR	0.03
JED-WH-F	55.6	1.8	JED-DR	0.10
JED-WH-C	31.5	1.0	HED-AC	0.87
JED-WH-A	33.9	1.1	HED-SC	0.63

Table 10: The CCR per each resource pool in March 2021

Step five: Defining activities.

Products Registration

Process	Task	Time (Sec)	Cost driver	Resource pool (No. of persona)		
				1	2	3
Product registration	Design artwork	**300**	Item	HED-SC		
	Forward email	**60**	Item	HED-SC		

Table 11: The Product registration activity's steps and durations

Demand Planning

Process	Task	Time (Sec)	Cost driver	Resource pool (No. of persona)		
				1	2	3
Demand Planning	Export quantity on hand report	**60**	Plan	HED-SC		
	Check past consumption:					
	Avg. of Last 4 weeks	**30**	Plan	HED-SC		
	Avg. of last 3 months	**30**	Plan	HED-SC		
	Avg. of same month last year	**30**	Plan	HED-SC		
	Develop your projection:					
	Develop Avg. of consumption	**45**	Item	HED-SC		
	simulate consumption for each SKU	**60**	Item	HED-SC		
	Send it to customer	**60**	Plan	HED-SC		
	Discuss it	**105**	Item	HED-SC		
	If multiple vendors: CBM calculation	**15**	Item	HED-SC		
	If multiple vendors: Share with client	**60**	Plan	HED-SC		

Table 12: The Demand planning activity's steps and duration

Procurement

Process	Task	Time (Sec)	Cost driver	Resource pool (No. of persona)		
				1	2	3
Procurement	Send quote request	**120**	PO	HED-SC		
	Create PO	**60/30**	PO/Item	HED-SC		
	Get approval from management	**300**	PO	HED-SC		
	Scan and email PO	**60**	PO	HED-SC		

	Receive and approve shipment docs (digital)	**420**	PO	HED-SC		
	Pay shipment cost:					
	Adding a new supplier	**180**	PO	HED-AC		
	Paying supplier	**120**	PO	HED-AC		
	Prepare pre-notification at SFDA:					
	Handing invoice to data entry	**180**	PO	HED-SC		
	Enter details	**45**	PO	HED-MG		
	Generate SABER certificate					
	Prepare docs.	**30**	PO	HED-SC		
	Send docs. To TUV (agent)	**60**	PO	HED-SC		
	Receive certificate and print it out	**60**	PO	HED-SC		
	Submit docs. To clearance agency	**120**	PO	HED-SC		
	Receive Bayan to pay for custom duty:					
	Forward Bayan to accounts	**30**	PO	HED-SC		
	Pay Bayan	**60**	PO	HED-AC		
	Pay clearing fee	**120**	PO	HED-AC		
	Generate GRN	**15**	Item	HED-SC		
	Submit docs. To accounts	**180**	PO	HED-SC		

Table 13: The Procurement activity's steps and durations

Receiving shipments

Process	**Task**	**Time (Sec)**	**Cost driver**	**Resource pool (No. of persona)**		
				1	**2**	**3**
Receiving shipments	Assign dock	**60**	Shipment	DMM-LB , RYD-LB , JED-LB		
	Collect docs.	**60**	Shipment	DMM-LB , RYD-LB , JED-LB		
	Check container condition	**180**	Shipment	DMM-LB , RYD-LB , JED-LB		
	Check temp.	**60**	Shipment	DMM-LB , RYD-LB , JED-LB		
	Confirm temp.	**180**	Shipment	DMM-LB , RYD-LB , JED-LB		
	Move items in	**54X2**	Pallet	DMM-LB , RYD-LB , JED-LB	DMM-LB , RYD-LB , JED-LB	
	Pick and check items quality	**180**	Shipment	DMM-LB , RYD-LB , JED-LB		

	Mark the damaged items	**30**	case	DMM-LB , RYD-LB , JED-LB		
	Keep damaged items away	**120X 2**	case	DMM-LB , RYD-LB , JED-LB	DMM-LB , RYD-LB , JED-LB	
	Check quantity/Expiry stickers on pallets	**9**	Pallet	DMM-LB , RYD-LB , JED-LB		
	Palletising items (if not palletised)	**420X 2**	Pallet	DMM-LB , RYD-LB , JED-LB	DMM-LB , RYD-LB , JED-LB	
	Wrapping	**60X2**	Pallet	DMM-LB , RYD-LB , JED-LB	DMM-LB , RYD-LB , JED-LB	
	Write and paste items No.	**30X2**	Pallet	DMM-LB , RYD-LB , JED-LB	DMM-LB , RYD-LB , JED-LB	
	Enter data for the newly palletised items	**50X2**	Pallet	DMM-LB , RYD-LB , JED-LB	DMM-LB , RYD-LB , JED-LB	
	Put away	**104X 2**	Pallet	DMM-LB , RYD-LB , JED-LB	DMM-LB , RYD-LB , JED-LB	
	Scan and change status on handheld	**10X2**	Pallet	DMM-LB , RYD-LB , JED-LB	DMM-LB , RYD-LB , JED-LB	

Table 14: The Receiving shipment activity's steps and durations.

Costing

Process	**Task**	**Time (Sec)**	**Cost driver**	**Resource pool (No. of persona)**		
				1	**2**	**3**
Costing	Open GRN	**30**	PO	HED-AC		
	Calculate the new shipment's cost	**540/60**	PO/Item	HED-AC		
	Confirm GRN	**60**	PO	HED-AC		
	Export report	**30**	PO	HED-AC		
	Send to finance manager	**120**	PO	HED-AC		
	Approve the new cost	**90**	PO	HED-AC		

Table 15: The Costing activity steps and durations

Claims Management

Process	**Task**	**Time (Sec)**	**Cost driver**	**Resource pool (No. of persona)**		
				1	**2**	**3**
Claims management	Raise a claim for damaged items	**60/5**	shipment/item	DMM-LB		
	Export and email report to finance	**60**	Claim	DMM-LB		
	Check damage value	**120**	Claim	HED-AC		
	Destroy items	**300X3**	Claim	DMM-LB	DMM-LB	HED-AC
	Prepare claim docs.	**420**	Claim	HED-AC		

	Sign by finance manager.	**120**	Claim	HED-AC		
	Send to insurance company	**60**	Claim	HED-AC		
	Agree on the FoA	**120**	Claim	HED-AC		
	Send signed FoA	**120**	Claim	HED-AC		

Table 16: The Claims Management activity's steps and durations

Branch Transfers

Process	Task	Time (Sec)	Cost driver	Resource pool (No. of persona)		
				1	2	3
Branch Transfer	Send/receive email	**60X2**	Transfer	HED-SC	DMM-LB , RYD-LB , JED-LB	
	Study quantity	**60**	Transfer	HED-SC		
	Check trucks availability	**180**	Transfer	HED-SC		
	Raise request	**40/2**	Transfer/item	HED-SC		
	Email request to the sending storekeeper	**30**	Transfer	HED-SC		
	Print the request out	**45**	Transfer	HED-SC		
	Deliver a hard-copy of the request to storekeeper	**120**	Transfer	HED-SC		
	Enter data when receiving transfer	**120**	Transfer	DMM-LB , RYD-LB , JED-LB		
	Confirm by email	**60**	Transfer	DMM-LB , RYD-LB , JED-LB		

Table 17: The Branch Transfer activity's steps and durations

Processing Orders

Process	Task	Time (Sec)	Cost driver	Resource pool (No. of persona)		
				1	2	3
Processing Orders	Enter order data	**50/3**	Invoice/item	HED-SC		
	Email PDF to the branch (customer)	**60**	Invoice	HED-SC		
	Deliver a hard-copy of the order to storekeeper	**120**	Invoice	HED-SC		

Table 18: The Processing Orders activity's steps and durations

Picking & Loading

Process	Task	Time (Sec)	Cost driver	Resource pool (No. of persona)		
				1	2	3
Picking & Loading	Bring an empty pallet	**120**	Invoice	DMM-LB , RYD-LB , JED-LB		
	Pick items	**150X2**	Item	DMM-LB , RYD-LB , JED-LB	DMM-LB , RYD-LB , JED-LB	
	Consolidate	**210X2**	Invoice	DMM-LB , RYD-LB , JED-LB	DMM-LB , RYD-LB , JED-LB	
	Wrapping	**60**	Pallet	DMM-LB , RYD-LB , JED-LB		
	Prepare truck for delivery	**90**	Trip	DMM-DR , RYD-DR , JED-DR		
	Loading	**75X2**	Pallet	DMM-LB , RYD-LB , JED-LB	DMM-LB , RYD-LB , JED-LB	
	Signing by driver	**15**	Invoice	DMM-LB , RYD-LB , JED-LB		

Table 19: The Picking & Loading activity's steps and durations

Delivery

City	Trip No.	Start from	Pass through	First Dist.	Second Dist.	Total Dist. (km)	Driving Time (min)
		DC* 1	DC 2	Loc* 1	Loc 2		
Dammam	1	DMI*	DME*	Branch. #1	-	27	46.5
Jeddah	2	JED*	-	Branch. #2	Branch. #3	110	166
Riyadh	3	RYI*	RYE*	Branch. #4	Branch. #5	78	144
Riyadh	4	RYI	RYE	Branch. #6	Branch. #7	77	142

Table 20: Trips plans for Hummy's orders delivery in Q1-2021

DC= Distribution Center

Loc= Location

DMI= Dammam Internal Warehouse

DME= Dammam External Warehouse

JED= Jeddah Warehouse

RYI= Riyadh Internal Warehouse

RYE= Riyadh External Warehouse

Process	Task	Time (Sec)	Cost driver	Resource pool (No. of persona)		
				1	2	3
Delivery	Prepare the truck	90	Delivery			
	Inspect truck	60	Delivery			
	Travel:					
	Trip #1	1860	Delivery	DMM-DR		
	Trip #2	10260	Delivery	JED-DR		
	Trip #3	9360	Delivery	RYD-DR		
	Trip #4	9300	Delivery	RYD-DR		
	Approach restaurant manager	300	Delivery	DMM-DR , RYD-DR , JED-DR		
	Turn off cooling	15	Delivery	DMM-DR , RYD-DR , JED-DR		
	Offload items	22	case	DMM-DR , RYD-DR , JED-DR		
	Prepare to leave	60	Delivery	DMM-DR , RYD-DR , JED-DR		
	Handover invoice to SC	120	Delivery	DMM-DR , RYD-DR , JED-DR		

Table 21: Delivery activity's steps and durations

Invoicing

Process	Task	Time (Sec)	Cost driver	Resource pool (No. of persona)		
				1	2	3
Invoicing	Prepare sales report	30	Invoice	HED-AC		
	Share sales report with client	60	Customer	HED-AC		
	Prepare receiving voucher	300	Customer	HED-AC		
	Enter receiving voucher	40	Customer	HED-AC		
	Match voucher with invoices	60	Customer	HED-AC		
	Process voucher	10	Customer	HED-AC		

Table 22: Invoicing activity's steps and durations

Step six: Time equations development

Product registration

HED-SC					
Month	# Of products	# Of designs	Total time spent (min)	CCR (SAR)	Total cost (SAR)

Jan	0	0	0	0.58	**0**
Feb	2	0	2	0.63	**1.26**
Mar	3	0	3	0.63	**1.89**

Table 23: Product Registration activity's record and cost in Q1-2021

Demand planning

Month	# of plans	# of SKU	# of consolidation
January	5	61	0
February	4	61	0
March	4	61	0

Table 24: Demand Planning activity's record in Q1-2021

HED-SC					
Month	**# of plans**	**# of SKU**	**Total time spent (min)**	**CCR (SAR)**	**Total cost (SAR)**
January	5	61	= 5 X 3.5 + (5 X 61 X 3.5) = 1085	0.58	**629.3**
February	4	61	= 4 X 3.5 X (4 X 61 X 3.5) = 868	0.63	**546.84**
March	4	61	= 4 X 3.5 X (4 X 61 X 3.5) = 868	0.63	**546.84**

Table 25: Demand Planning activity's costs in Q1-2021

Procurement

PO #	Date	# Of Items	# of Food items	# of Non-food items	Vendor	New vendor
1	14-Jan-21	1	1	0	International	No
2	17-Jan-21	25	20	5	International	No
3	14-Jan-21	1	-	-	Local	No
4	14-Jan-21	1	-	-	Local	No
5	15-Jan-21	1	-	-	Local	No
6	2-Feb-21	1	1	0	International	No
7	17-Feb-21	23	14	9	International	No
8	11-Feb-21	1	-	-	Local	No

9	11-Feb-21	1	-	-	Local	No
10	11-Feb-21	1	-	-	Local	No
11	15-Feb-21	1	-	-	Local	No
12	4-Mar-21	1	1	0	International	No
13	8-Mar-21	27	17	10	International	No
14	4-Mar-21	1	-	-	Local	No
15	4-Mar-21	1	-	-	Local	No
16	4-Mar-21	2	-	-	Local	No
17	13-Mar-21	2	-	-	Local	No
18	21-Mar-21	1	1	0	International	No

Table 26: Procurement activity's record in Q1-2021

HED-SC				
Month	**Total time spent (min) on:**		**CCR (SAR)**	**Total cost (SAR)**
	Intl. POs	**Local POs**		
Jan	137	38.25	0.58	159.185
Feb	127.5	51	0.63	159.63
Mar	166.75	52.5	0.63	199.825

Table 27: Procurement activity's costs in Q1-2021 (HED-SC)

HED-AC				
Month	**Total time spent (min) on:**		**CCR (SAR)**	**Total cost (SAR)**
	Intl.	**Local**		
Jan	6	6	0.87	10.44
Feb	6	8	0.87	12.18
Mar	9	8	0.87	14.79

Table 28: "Procurement" activity's costs in Q1-2021 (HED-AC)

Month	HED-SC (SAR)	HED-AC (SAR)	Total cost (SAR)
Jan	159.185	10.44	169.625
Feb	159.63	12.18	171.81
Mar	199.825	14.79	214.615
Total	518.64	37.41	556.05

Table 29: Total Procurement activity's costs in Q1-2021 (HED-SC + HED-AC)

Receiving Shipments

Month	# Of shipments	# of Frozen	# of Chilled	# of Ambient	Sum of quantity (cases)	Count of ITEM_CODE
Jan	5	2	1	2	3960	28
Feb	5	2	0	3	4432	5
Mar	5	1	1	3	1591	28
Total	15				9983	61

Table 30: Record of received shipments in Q1-2021

Jan 2021

Storage type	Location	# of Equivalent Pallets	# of Damaged cases	# of Not-Palletised cases
Frozen	DMM-WH-F	126	2	0
Chilled	DMM-WH-C	4	0	0
Ambient	DMM-WH-E	28	0	0

Table 31: Record of products received in January 2022

Feb 2022

Storage type	Location	# of Equivalent Pallets	# of Damaged cases	# of Not-Palletised cases
Frozen	DMM-WH-F	250	2	0
Chilled	DMM-WH-C	0	0	0
Ambient	DMM-WH-E	69	0	0

Table 32: Record of products received in February 2022

Mar 2022

Storage type	Location	# of Equivalent Pallets	# of Damaged cases	# of Not- Palletised cases
Frozen	DMM-WH-F	20	0	0
Chilled	DMM-WH-C	2	0	0
Ambient	DMM-WH-E	34	3	0

Table 33: Record of products received in March 2022

Jan 2021

DMM-LB			
Storage type	**Total time spent (min)**	**CCR (SAR)**	**Total cost (SAR)**
Frozen	1345.02	0.86	1156.7172
Chilled	190	0.86	163.4
Ambient	301.76	0.86	259.5136
Grand total	1800.5	0.86	**1554.83**

Table 34: Receiving Shipments activity's cost in January 2021

Feb 2021

DMM-LB			
Storage type	**Total time spent (min)**	**CCR (SAR)**	**Total cost (SAR)**
Frozen	2629	0.88	2313.52
Chilled	0	0.88	0
Ambient	733.98	0.88	645.9024
Grand total	3362.98	0.88	**2959.4224**

Table 35: Receiving Shipments activity's cost in February 2021

Mar 2021

DMM-LB			
Storage type	**Total time spent (min)**	**CCR (SAR)**	**Total cost (SAR)**
Frozen	220.4	0.88	193.952
Chilled	32.84	0.88	28.8992
Ambient	381.43	0.88	335.6584
Grand Total	634.67	0.88	**558.5096**

Table36: Receiving Shipments activity's cost in March 2021

Warehousing

Jan 2021

RP	Available capacity (CBM)	Capacity occupied by Hummy (CBM)	Capacity Utilisation	CCR/month (SAR)	total cost (SAR)
DMM-WH-A	2,839	6	0.2%	45	279
DMM-WH-C	3,285	13	0.4%	40	525
DMM-WH-F	7,523	80	1.1%	44	3,523
DMM-WH-E	6,190	130	2.1%	22	2,841
JED-WH-A	2,621	110	4.2%	29	3,234
JED-WH-C	1,660	11	0.7%	28	317
JED-WH-F	699	76	10.8%	39	2,924
RYD-WH-A	505	23	4.5%	37	832
RYD-WH-C	638	38	6.0%	32	1,218
RYD-WH-F	1,843	224	12.2%	31	6,994
RYD-WH-E	2,333	409	17.5%	28	11,539
Grand total	30,134	1,120	3.7%		**34,226**

Table 37: Storage activity's record and cost in January 2021

Feb 2021

RP	Available capacity (CBM)	Capacity occupied by Hummy (CBM)	Capacity Utilisation	CCR/month (SAR)	total cost (SAR)
DMM-WH-A	2,839	5	0.2%	42	190
DMM-WH-C	3,285	11	0.3%	37	424
DMM-WH-F	7,523	70	0.9%	39	2,725
DMM-WH-E	6,190	118	1.9%	20	2,360
JED-WH-A	2,621	95	3.6%	28	2,669
JED-WH-C	1,660	8	0.5%	29	222
JED-WH-F	699	49	7.1%	55	2,700
RYD-WH-A	505	27	5.4%	45	1,242
RYD-WH-C	638	35	5.5%	41	1,408
RYD-WH-F	1,843	208	11.3%	40	8,254
RYD-WH-E	2,333	444	19.0%	29	12,918
Grand total	30,134	1,070	3.6%		**35,113**

Table 38: Storage activity's record and cost in February 2021

Mar 2021

RP	Available capacity (CBM)	Capacity occupied by Hummy (CBM)	Capacity Utilisation	CCR/month (SAR)	total cost (SAR)
DMM-WH-A	2,839	6	0.2%	49	319
DMM-WH-C	3,285	14	0.4%	45	610
DMM-WH-F	7,523	84	1.1%	48	3,981
DMM-WH-E	6,190	157	2.5%	20	3,107
JED-WH-A	2,621	141	5.4%	34	4,763
JED-WH-C	1,660	11	0.7%	32	359
JED-WH-F	699	73	10.4%	56	4,035
RYD-WH-A	505	24	4.8%	41	990
RYD-WH-C	638	43	6.8%	36	1,555
RYD-WH-F	1,843	265	14.4%	35	9,365
RYD-WH-E	2,333	559	24.0%	28	15,547
Grand total	30,134	1,377	4.6%		**44,632**

Table 39: Storage activity's record and cost in March 2021

Costing

Month	# of shipments	# of items	Total time spent (min)	CCR (SAR)	Total cost (SAR)
January	5	28	= 5 X 14.5 + (1 X 28) = 105.5	0.87	**87.4**
February	5	5	= 5 X 14.5 + (1 X 5) = 78.5	0.87	**67.42**
March	5	28	= 5 X 14.5 + (1 X 28) = 115	0.87	**87.4**

Table 40: Costing activity's time spent and total cost in Q1-2021

Claims Management

Month	Below value-limit claims	# Of items	Above value-limit claims	# Of items	Total Claims
Jan	2	2	0	0	2
Feb	2	2	0	0	2
Mar	1	1	2	2	3

Table 41: Claims Management activity's record in Q1-2021

HED-AC					
Month	**# of Below limit**	**# of Above limit**	**Total time spent (min)**	**CCR (SAR)**	**Total cost (SAR)**
January	2	0	2 X 5 + (2 X 2) + (if above value limit, 14, 0) = 18	0.87	**15.66**
February	2	0	2 X 5 + (2 X 2) + (if above value limit, 14, 0) = 18	0.87	**15.66**
March	1	2	3 X 5 + (2 X 3) + (if above value limit, 14, 0) = 49	0.87	**42.63**

Table 42: Claims Management activity's record and cost in Q1-2021 (HED-AC)

DMM- LB					
Month	**# of Claims**	**# of Items**	**Total time spent (min)**	**CCR (SAR)**	**Total cost (SAR)**
January	2	2	2 X 2 + (10.08 X 2) = 24.16	0.86	**20.7776**
February	2	2	2 X 2 + (10.08 X 2) = 24.16	0.88	**21.2608**
March	3	3	3 X 2 + (10.08 X 3) = 36.24	0.88	**31.8912**

Table 43: Claims Management activity's record and cost in Q1-202 (DMM-LB)

Month	HED-AC (SAR)	DMM-LB (SAR)	Total Cost (SAR)
Jan	15.66	20.78	36.44
Feb	15.66	21.26	36.92
Mar	42.63	31.89	74.52

Table 44: The total cost of Claims Management activity (HED-AC+ DMM-LB)

Branch Transfer

HED-SC					
Month	**# of Requests**	**# of Items**	**Time spent (min)**	**CCR (SAR)**	**Total cost (SAR)**
Jan	15	91	15 X 8.9 + (91 X 0.06) = 139.8	0.58	81.09367
Feb	17	81	17 X 8.9 + (81 X 0.06) = 156.98	0.63	98.8995
Mar	21	87	21 X 8.9 + (87 X 0.06) = 193.05	0.63	121.6215
Grand total	53	259			**301.6147**

Table 45: Branch Transfer activity's record and cost in Q1-2021 (HED-SC)

Month	# Of (picklists)	Count of ITEM_CODE	Sum of Total CBM	Equivalent Pallets
Dammam Internal	**17**	**46**	**195.6364**	**158.00**
Jan	7	17	66.2154	54.00
Feb	5	12	121.2052	98.00
Mar	5	17	8.2158	7.00
Jeddah	**4**	**13**	**0.81**	**2.00**
Feb	3	11	0.7286	1.00
Mar	1	2	0.0814	1.00
Riyadh Internal	**1**	**1**	**0.15**	**1.00**
Jan	1	1	0.15	1.00
Dammam External	**29**	**197**	**106.6792**	**87.00**
Jan	7	73	20.355	17.00
Feb	9	59	65.5666	53.00
Mar	13	65	20.7576	17.00
Riyadh External	**2**	**2**	**0.0127**	**1.00**
Mar	2	2	0.0127	1.00
Grand Total	**53**	**259**	**303.2883**	**249.00**

Table 46: Branch Transfer activity's record in Q1-2021(transfers out)

Month	Time spent (min)	CCR (SAR)	Total cost (SAR)
DMM-LB			
Jan	424.5	0.86	365.07
Feb	553.5	0.88	487.08
Mar	303	0.88	266.64
JED-LB			
Jan	0	1.22	0
Feb	90.75	1.16	105.27
Mar	24.25	1.12	27.16
RYD-LB			
Jan	19.25	0.9	17.325

Feb	0	0.63	0
Mar	35	0.89	31.15
Total			
Jan	443.75	-	**382.395**
Feb	644.25	-	**592.35**
Mar	362.25	-	**324.95**

Table 47: Branch Transfer activity's labour cost in Q1-2021(transfers out)

Month	# Of shipments	# Of pallets	Damage cases
DMM-LB			
Jan	1	1	0
Feb	2	5	0
Mar	2	2	0
JED-LB			
Jan	5	28	0
Feb	3	19	0
Mar	5	7	0
RYD-LB			
Jan	9	45	0
Feb	12	103	0
Mar	14	23	0

Table 48: The record of Branch Transfer requests in Q1-2021(transfers in)

Month	Time spent (min)	CCR (SAR)	Total cost (SAR)
DMM-LB			
Jan	22.42	0.86	19.2812
Feb	76.1	0.88	66.968
Mar	44.84	0.88	39.4592
JED-LB			
Jan	351.76	1.22	429.1472
Feb	233.98	1.16	271.4168
Mar	132.94	1.12	148.8928

RYD-LB			
Jan	576.9	0.9	519.21
Feb	1217.26	0.63	766.8738
Mar	407.66	0.89	362.8174
Total			
Jan	951.08	-	**967.6384**
Feb	1527.34	-	**1105.2586**
Mar	585.44	-	**551.1694**

Table 49: Time and cost of Branch Transfer activity in the receiving warehouses in Q1-2021

Jan 2021

From	To	Sum of QUANTITY (CASES)	Sum of CUBES (CBM)	Driving Time Avg 100 km/h (min)	Distance in km	% of the total Truck Capacity 29.76 cbm
002	004	172	0.9284	124.5	209	3.12%
205	419	182	2.0038	123	207.5	6.73%
004	002	10	0.15	254	416	0.50%
205	003	132	2.2386	619	978	7.52%
205	419	146	3.1542	246	415	10.60%
002	004	100	0.41	124.5	209	1.38%
205	419	259	2.701	123	207.5	9.08%
002	003	470	2.588	825	1374	8.70%
002	004	400	2	249	418	6.72%
205	419	266	4.5461	246	415	15.28%
002	004	570	3.6296	249	418	12.20%
002	003	200	1	825	1374	3.36%
002	003	213	1.5194	412.5	687	5.11%
205	003	128	2.1786	412.5	687	7.32%
205	419	178	2.8374	246	415	9.53%

Table 50: The record of Branch Transfer trips in January 2021

Feb 2021

From	To	Sum of QUANTITY (CASES)	Sum of CUBES (CBM)	Driving Time Avg 100 km/h (min)	Distance in km	% of the total Truck Capacity 29.76 cbm
205	419	188	2.8372	207.5	123	9.53%
205	003	309	2.6361	687	412.5	8.86%
205	419	448	3.8976	415	246	13.10%
002	004	500	2.84	418	249	9.54%
205	419	280	2.436	415	246	8.19%
003	419	10	0.069	489	295	0.23%
002	004	704	3.86	209	124.5	12.97%
002	004	248	2.0312	418	249	6.83%
205	002	602	3.3804	1	2	11.36%
205	419	94	0.9392	415	246	3.16%
003	205	33.5	0.4691	1375	827	1.58%
003	419	17	0.1065	978	590	0.36%
205	003	207	4.0448	687	412.5	13.59%
002	003	400	2.34	687	412.5	7.86%
002	004	1350	7.26	418	249	24.40%
205	419	120	3.012	415	246	10.12%
205	419	234	3.6138	415	246	12.14%

Table 51: The record of Branch Transfer trips in February 2021

Mar 2021

From	To	Sum of QUANTITY (CASES)	Sum of CUBES (CBM)	Driving Time Avg 100 km/h (min)	Distance in km	% of the total Truck Capacity 29.76 cbm
003	419	13.83	0.05	489	295	0.16%
419	003	0.33	0.00	489	309.5	0.01%
002	004	233	1.8062	418	249	6.07%
205	419	107	1.5557	415	246	5.23%
205	003	25	0.2975	1374	825	1.00%

205	419	12	0.672	207.5	123	2.26%
419	205	0.167	0.001	205.5	125	0.00%
002	004	146	0.8204	418	249	2.76%
205	419	145	2.4281	415	246	8.16%
205	419	52.5	0.1805	415	246	0.61%
205	003	79.5	1.5526	1374	825	5.22%
205	419	121	1.7235	415	246	5.79%
205	002	314	2.2707	0.5	1	7.63%
002	004	278	2.2472	209	124.5	7.55%
205	419	139	1.6399	415	246	5.51%
002	003	160	1.235	343.5	206.3	4.15%
002	004	30	0.45	104.5	62.25	1.51%
205	003	41	0.8626	343.5	206.3	2.90%
205	419	288	2.9564	103.75	61.5	9.93%
205	419	150	3.765	415	246	12.65%

Table 52: The record of Branch Transfer trips in March 2021

Month	Driving time (min)	CCR (SAR)	Total cost (SAR)
DMM-DR			
Jan	4825	0.26	1254.5
Feb	5807.5	0.24	1393.8
Mar	7386.25	0.23	1698.8375
RYD-DR			
Jan	254	0.04	10.16
Feb	0	0.03	0
Mar	694.5	0.03	20.835
JED-DR			
Jan	0	0.1	0
Feb	2842	0.1	284.2
Mar	489	0.1	48.9

Table 53: Total Branch Transfer activity cost in Q1-2021 (Drivers cost)

Month	Driving time (min)	CCR (SAR)	Total cost (SAR)
DMM-TR			
Jan	8014	0.81	6491.34
Feb	3464	0.83	2875.12
Mar	4408.85	0.72	3174.372
RYD-TR			
Jan	416	0.53	220.48
Feb	0	0.49	
Mar	434.5	0.49	212.905
JED-TR			
Jan	0	0.89	0
Feb	1712	0.87	1489.44
Mar	295	0.88	259.6

Table 54: Total cost of Branch Transfer activity in Q1-2021 (Trucks cost)

Month	Driving time (min)	CCR (SAR)	Total cost (SAR)
DMM-DR			
Jan	356.59	0.26	92.71
Feb	619.49	0.24	148.68
Mar	336.47	0.23	77.39
RYD-DR			
Jan	1.3	0.04	0.1
Feb	0.0	0.03	0.0
Mar	0.0	0.03	0.0
JED-DR			
Jan	0.00	0.10	0.00
Feb	26.37	0.10	2.64
Mar	0.78	0.10	0.08

Table 55: Branch Transfer activity cost allocated to Hummy in Q1-2021 (Drivers cost)

Month	Driving time (min)	CCR (SAR)	Total cost (SAR)
DMM-TR			
Jan	592.89	0.81	480.24
Feb	369.55	0.83	306.73
Mar	200.51	0.72	144.36
RYD-TR			
Jan	2.08	0.53	1.10
Feb	0.00	0.49	0.00
Mar	0.03	0.49	0.02
JED-TR			
Jan	0.00	0.89	0.00
Feb	15.87	0.87	13.81
Mar	0.47	0.88	0.42

Table 56: Branch Transfer activity cost allocated to Hummy in Q1-2021 (Trucks cost)

Processing Orders

Month	# Of orders	# Of items	Total Time Spent (min)	CCR (SAR)	Total cost (SAR)
Jan	322	1939	1331.28	0.58	**772.14**
Feb	310	1707	1273.68	0.63	**802.42**
Mar	347	2208	1440.57	0.63	**907.56**

Table 57: Processing Orders activity cost in Q1-2021

Picking & Loading

City	Branch ID	Jan		Feb		Mar		Total	
		Orders	Cases	Orders	Cases	Orders	Cases	Orders	Cases
DMM	Branch 1	56	876	47	772	58	958	161	2606
JED	Branch 2	23	458	23	408	28	472	74	1338
	Branch 3	20	378.5	16	182	22	379	58	939.5
RYD	Branch 4	56	679.5	56	488	59	595	171	1762.5

	Branch 5	56	800.5	55	781	61	1006	172	2587.5
	Branch 6	55	581	54	633	60	732	169	1946
	Branch 7	55	792	59	781	59	951	173	2524
Grouop customer	2-5500 CRAVI	1	25	0	0	0	0	1	25
Grand total		**322**	**4590.5**	**310**	**4045**	**347**	**5093**	**979**	**13728.5**

Table 58: The operational record of orders places by Hummy's branches in Q1-2021

Month	Time spent (min)	CCR (SAR)	Total cost (SAR)
DMM-LB			
Jan	5178	0.86	4453.08
Feb	4529.75	0.88	3986.18
Mar	5616.5	0.88	4942.52
JED-LB			
Jan	4795.25	1.22	5850.205
Feb	3505.75	1.16	4066.67
Mar	6024.25	1.12	6747.16
RYD-LB			
Jan	17428.5	0.9	15685.65
Feb	16607	0.63	10462.41
Mar	19825.8	0.89	17644.918
Total			
Jan	27401.8		25988.935
Feb	24642.5		18515.26
Mar	31466.5		29334.598

Table 59: The total cost of Picking & Loading activity for all Hummy's branches in Q1-2021

Delivery

Trip 1				
Month	**# Of trips**	**Distance (km)**	**Time (min)**	**# Of cases**
Jan	21	567	976.5	902

Feb	18	486	837	775
Mar	23	621	1069.5	961

Trip 2

Month	# Of trips	Distance (km)	Time (min)	# Of cases
Jan	23	2530	3818	837
Feb	23	2530	3818	591
Mar	27	2970	4482	858

Trip 3

Month	# Of trips	Distance (km)	Time (min)	# Of cases
Jan	26	2028	3744	1375
Feb	28	2184	4032	1422
Mar	31	2387	4402	1693

Trip 4

Month	# Of trips	Distance (km)	Time (min)	# Of cases
Jan	26	2002	3692	1481
Feb	28	2156	3976	1272
Mar	31	2387	4402	1614

Table 60: Trips operational record in Q2021

Trip 1 (Assigned from: DMM-TR)			
Month	**Distance (km)**	**CCR (SAR)**	**Total cost (SAR)**
Jan	567	0.81	458.06
Feb	486	0.83	401.86
Mar	621	0.72	450.06

Trip 2 (Assigned from: JED-TR)			
Month	**Distance (km)**	**CCR (SAR)**	**Total cost (SAR)**
Jan	2530	0.89	2243.63

Feb	2530	0.87	2191.39
Mar	2970	0.88	2610.43
Trip 3 (Assigned from: RYD-TR)			
Month	**Distance (km)**	**CCR (SAR)**	**Total cost (SAR)**
Jan	2028	0.53	1069.19
Feb	2184	0.49	1078.65
Mar	2387	0.49	1176.91
Trip 4 (Assigned from: RYD-TR)			
Month	**Distance (km)**	**CCR (SAR)**	**Total cost (SAR)**
Jan	2002	0.53	1055.48
Feb	2156	0.49	1064.82
Mar	2387	0.49	1176.91

Table 61: Total cost of Delivery activity per each trip in Q1-2021 (Trucks cost)

Trip 1 (Assigned for: DMM-DR)			
Month	**Time spent (min)**	**CCR (SAR)**	**Total cost (SAR)**
Jan	1532.382	0.26	391.36
Feb	1314.15	0.24	318.93
Mar	1668.476	0.23	385.32
Trip 2 (Assigned for: JED-DR)			
Month	**Time spent (min)**	**CCR (SAR)**	**Total cost (SAR)**
Jan	4371.592	0.10	456.47
Feb	4281.556	0.10	443.35
Mar	5086.278	0.10	521.44
Trip 3 (Assigned for: RYD-DR)			
Month	**Time spent (min)**	**CCR (SAR)**	**Total cost (SAR)**
Jan	4526.75	0.04	170.51
Feb	4853.452	0.03	153.12
Mar	5354.888	0.03	179.03
Trip 4 (Assigned for: RYD-DR)			
Month	**Time spent (min)**	**CCR (SAR)**	**Total cost (SAR)**
Jan	4513.546	0.04	170.02
Feb	4742.552	0.03	149.62
Mar	5325.974	0.03	178.06

Table 62: Total cost of Delivery activity per each trip in Q1-2021 (drivers cost)

Trip 1			
Month	**"DMM-TR" (SAR)**	**"DMM-DR" (SAR)**	**Total cost (SAR)**
Jan	458.06	391.36	849.43
Feb	401.86	318.93	720.79
Mar	450.06	385.32	835.38

Total	**1309.98**	**1095.61**	**2405.59**
		Trip 2	
Month	**"JED-TR" (SAR)**	**"JED-DR" (SAR)**	**Total cost (SAR)**
Jan	2243.63	456.47	2700.09
Feb	2191.39	443.35	2634.74
Mar	2610.43	521.44	3131.87
Total	**7045.44**	**1421.26**	**8466.70**
		Trip 3	
Month	**"RYD-TR" (SAR)**	**"RYD-DR" (SAR)**	**Total cost (SAR)**
Jan	1069.19	170.51	1239.71
Feb	1078.65	153.12	1231.77
Mar	1176.91	179.03	1355.94
Total	**3324.76**	**502.66**	**3827.42**
		Trip 4	
Month	**"RYD-TR" (SAR)**	**"RYD-DR" (SAR)**	**Total cost (SAR)**
Jan	1055.48	170.02	1225.50
Feb	1064.82	149.62	1214.44
Mar	1176.91	178.06	1354.98
Total	**3297.22**	**497.70**	**3794.92**

Table 63: The total cost of Delivery activity for all four trips in Q1-2021

Invoicing

Month	# Of customers	# Of invoices	Total time spent (min)	CCR (SAR)	Total cost (SAR)
January	1	322	168.83	0.87	**146.82**
February	1	310	162.83	0.87	**141.59**
March	1	347	181.33	0.87	**157.68**

Table 64: Total cost of Invoicing activity assigned to Hummy in Q1-2021

Step seven: Allocation to cost objects

The indirect allocation method

Customer ID	Jan		Feb		Mar	
	# Of orders	%	# Of orders	%	# Of orders	%
2-5500 CRAVI	1	-	0	0	0	0
Branch 1	56	17%	47	15%	58	17%
Branch 2	23	7%	23	7%	28	8%
Branch 3	20	6%	16	5%	22	6%
Branch 4	56	17%	56	18%	59	17%
Branch 5	56	17%	55	18%	61	18%
Branch 6	55	17%	54	17%	60	17%
Branch 7	55	17%	59	19%	59	17%
Grand Total	322	100%	310	100%	347	100%

Table 65: The number of orders placed by Hummy's branches in Q1-2021

January 2021

Activity	Total cost	Branch 1	Branch 2	Branch 3	Branch 4	Branch 5	Branch 6	Branch 7
		17.4%	7.1%	6.2%	17.4%	17.4%	17.1%	17.1%
Demand Planning	629.30	110.0	45.4	40.0	109.4	109.4	107.5	107.5
Procurement	169.63	29.5	12.1	10.5	29.5	29.5	29.0	29.0
Receiving shipments	1579.63	274.7	112.8	98.1	274.7	274.7	269.8	269.8
Costing	87.4	15.2	6.2	5.4	15.2	15.2	14.9	14.9
Claims management	36.44	6.3	2.6	2.3	6.3	6.3	6.2	6.2
Total per customer		436.68	179.57	156.67	436.13	436.13	428.34	428.34

Table 66: The allocation of indirect activities to Hummy's branches in Jan. 2021

February 2021

Activity	Total cost	Branch 1	Branch 2	Branch 3	Branch 4	Branch 5	Branch 6	Branch 7
		15.16%	**7.42%**	**5.16%**	**18.06%**	**17.74%**	**17.42%**	**19.03%**
Demand Planning	546.84	82.91	40.57	28.22	98.78	97.02	95.26	104.08
Procurement	171.81	26.05	12.75	8.87	31.04	30.48	29.93	32.70
Receiving shipments	2966.55	449.77	220.10	153.11	535.89	526.32	516.75	564.60
Costing	67.39	10.22	5.00	3.48	12.17	11.96	11.74	12.83
Claims management	36.92	5.60	2.74	1.91	6.67	6.55	6.43	7.03
Total per customer		574.82	281.30	195.68	684.89	672.66	660.43	721.59

Table 67: The allocation of indirect activities to Hummy's branches in Feb. 2021

March 2021

Activity	Total cost	Branch 1	Branch 2	Branch 3	Branch 4	Branch 5	Branch 6	Branch 7
		16.71%	**8.07%**	**6.34%**	**17.00%**	**17.58%**	**17.29%**	**17.00%**
Demand Planning	546.84	91.40	44.13	34.67	92.98	96.13	94.55	92.98
Procurement	171.81	28.72	13.86	10.89	29.21	30.20	29.71	29.21
Receiving shipments	558.51	93.35	45.07	35.41	94.96	98.18	96.57	94.96
Costing	87.4	15.2	6.2	5.4	15.2	15.2	14.9	14.9
Claims management	74.52	12.46	6.01	4.72	12.67	13.10	12.89	12.67
Total per customer		242.81	117.22	92.10	247.00	255.37	251.18	247.00

Table 68: The allocation of indirect activities to Hummy's branches in Mar. 2021

January 2021

Warehousing	Location	DMM	JED		RYD			
	Cost	7,168	6,475		20,584			
	# of CBM	229	197		693			
	Branch	Branch 1	Branch 2	Branch 3	Branch 4	Branch 5	Branch 6	Branch 7
	# of CBM	38.27	17.46	16.67	26.35	34.16	17.04	29.12
	Allocation %	17%	9%	8%	4%	5%	2%	4%
	Allocated cost	1197.49	573.40	547.48	782.43	1014.34	505.81	864.58
	Not allocated	5,970.60	5,353.69		17,416.62			

Table 69: Allocation of Warehousing costs to Hummy's branches in Jan. 2021

February 2021

Warehousing	Location	DMM	JED		RYD			
	Cost	5,699	5,591		23,823			
	# of CBM	204	152		714			
	Branch	Branch 1	Branch 2	Branch 3	Branch 4	Branch 5	Branch 6	Branch 7
	# of CBM	41.62	12.97	4.70	14.03	33.36	19.57	26.76
	Allocation %	20.38%	8.56%	3.10%	1.97%	4.67%	2.74%	3.75%
	Allocated cost	1161.50	478.42	173.44	468.15	1112.75	652.69	892.83
	Not allocated	4,537.56	4,939.05		20,696.58			

Table 70: Allocation of Warehousing costs to Hummy's branches in Feb. 2021

March 2021

Warehousing	RP	DMM	JED		RYD			
	Cost	8,017	9,157		27,458			
	# of CBM	261	225		891			
	Branch	Branch 1	Branch 2	Branch 3	Branch 4	Branch 5	Branch 6	Branch 7
	# of CBM	48.55	15.49	12.23	16.20	46.33	25.13	38.68
	Allocation %	18.60%	6.89%	5.44%	1.82%	5.20%	2.82%	4.34%
	Allocated cost	1490.90	631.20	498.34	499.09	1426.96	773.94	1191.46
	Not allocated	6,525.74	8,027.90		23,566.14			

Table 71: Allocation of Warehousing costs to Hummy's branches in Mar. 2021

The direct allocation method.

January 202

Sales Order Processing	RP	HED-SC						
	Total Cost	772.14						
	# of sales orders	321*						
	Branch	**Branch 1**	**Branch 2**	**Branch 3**	**Branch 4**	**Branch 5**	**Branch 6**	**Branch 7**
	# of sales orders	56	23	20	56	56	55	55
	Allocation %	**17.4%**	**7.1%**	**6.2%**	**17.4%**	**17.4%**	**17.1%**	**17.1%**
	Allocated cost	**135.00**	**55.60**	**47.96**	**135.00**	**134.80**	**131.89**	**131.89**

Invoicing	RP	HED-AC						
	Total Cost	146.82						
	# of invoices	321*						
	Branch	**Branch 1**	**Branch 2**	**Branch 3**	**Branch 4**	**Branch 5**	**Branch 6**	**Branch 7**
	# of invoices	56	23	20	56	56	55	55
	Allocation %	**17.4%**	**7.1%**	**6.2%**	**17.4%**	**17.4%**	**17.1%**	**17.1%**
	Allocated cost	**25.53**	**10.49**	**9.57**	**25.53**	**25.53**	**25.08**	**25.08**

Picking & Loading	RP	DMM-LB	JED-LB		RYD-LB			
	Total Cost	4453.08	5850.205		15685.65			
	# of cases	876	836.5		2853			
	Branch	**Branch 1**	**Branch 2**	**Branch 3**	**Branch 4**	**Branch 5**	**Branch 6**	**Branch 7**
	# of cases	876	458	378.5	679.5	800.5	581	792
	Allocation %	100%	55%	45%	24%	28%	20%	28%
	Allocated cost	**4453.08**	**3203.10**	**2647.10**	**3735.86**	**4401.11**	**3194.31**	**4354.38**

Delivery	Trip	**Trip#1**	**Trip#2**		**Trip#3**		**Trip#4**	
	Cost	849	2,700		1239.71		1,226	
	# of cases	902	836.5		1373		1,480	
	Branch	**Branch 1**	**Branch 2**	**Branch 3**	**Branch 6**	**Branch 7**	**Branch 4**	**Branch 5**

	# of cases	876.00	458.00	378.50	581.00	792.00	679.50	800.50
	Allocation %	97%	55%	45%	42%	58%	46%	54%
	Alloated cost	**824.94**	**1478.35**	**1221.74**	**524.60**	**715.11**	**562.65**	**662.85**

Table 72: Delivery costs allocation to Hummy's branch in Jan. 2021

February 2021

Order processing	RP	**HED-SC**						
	Cost	802.42						
	# of sales orders	310						
	Branch	**Branch 1**	**Branch 2**	**Branch 3**	**Branch 4**	**Branch 5**	**Branch 6**	**Branch 7**
	# of sales orders	47	23	16	56	55	54	59
	Allocation %	**15.16%**	**7.42%**	**5.16%**	**18.06%**	**17.74%**	**17.42%**	**19.03%**
	Allocated cost	**121.66**	**59.53**	**41.42**	**144.95**	**142.36**	**139.78**	**152.72**
Invoicing	RP	**HED-AC**						
	Cost	141.59						
	# of invoices	310						
	Branch	**Branch 1**	**Branch 2**	**Branch 3**	**Branch 4**	**Branch 5**	**Branch 6**	**Branch 7**
	# of invoices	47	23	16	56	55	54	59
	Allocation %	**15.16%**	**7.42%**	**5.16%**	**18.06%**	**17.74%**	**17.42%**	**19.03%**
	Allocated cost	**21.47**	**10.51**	**7.31**	**25.58**	**25.12**	**24.66**	**26.95**
Picking & Loading	RP	**DMM-LB**	**JED-LB**		**RYD-LB**			
	Cost	3986.18	4066.67		10462.41			
	# of cases	772	590		2683			
	Branch	**Branch 1**	**Branch 2**	**Branch 3**	**Branch 4**	**Branch 5**	**Branch 6**	**Branch 7**
	# of cases	772	408	182	488	781	633	781
	Allocation %	100%	69%	31%	18%	29%	24%	29%
	Allocated cost	**3986.18**	**2812.21**	**1254.46**	**1902.97**	**3045.52**	**2468.40**	**3045.52**

Delivery	Trip	**Trip#1**	**Trip#2**	**Trip#3**	**Trip#4**

	Cost	721	2,635		1231.77		1,214	
	# of cases	772	590		1414		1,269	
	Branch	Branch 1	Branch 2	Branch 3	Branch 6	Branch 7	Branch 4	Branch 5
	# of cases	772.00	408.00	182.00	633.00	781.00	488.00	781.00
	Allocation %	100%	69%	31%	45%	55%	38%	62%
	Allocated cost	**720.79**	**1821.99**	**812.75**	**551.42**	**680.35**	**467.02**	**747.42**

Table 73: Delivery costs allocation to Hummy's branch in Feb. 2021

March 2021

Order processing	RP	HED-SC						
	Cost	907.56						
	# of sales orders	347						
	Branch	Branch 1	Branch 2	Branch 3	Branch 4	Branch 5	Branch 6	Branch 7
	# of sales orders	58	28	22	59	61	60	59
	Allocation %	**16.71%**	**8.07%**	**6.34%**	**17.00%**	**17.58%**	**17.29%**	**17.00%**
	Allocated cost	**151.70**	**73.23**	**57.54**	**154.31**	**159.54**	**156.93**	**154.31**
Invoicing	RP	HED-AC						
	Cost	157.68						
	# of invoices	347						
	Branch	Branch 1	Branch 2	Branch 3	Branch 4	Branch 5	Branch 6	Branch 7
	# of invoices	58	28	22	59	61	60	59
	Allocation %	**16.71%**	**8.07%**	**6.34%**	**17.00%**	**17.58%**	**17.29%**	**17.00%**
	Allocated cost	**26.36**	**12.72**	**10.00**	**26.81**	**27.72**	**27.26**	**26.81**
Picking & Loading	RP	DMM-LB	JED-LB		RYD-LB			
	Cost	4942.52	6747.16		17644.9175			
	# of cases	958	851		3284			
	Branch	Branch 1	Branch 2	Branch 3	Branch 4	Branch 5	Branch 6	Branch 7
	# of cases	958	472	379	595	1006	732	951
	Allocation %	100%	55%	45%	18%	31%	22%	29%

	Allocated cost	**4942.52**	**3742.26**	**3004.90**	**3196.93**	**5405.23**	**3933.03**	**5109.72**

	Trip	**Trip#1**	**Trip#2**		**Trip#3**		**Trip#4**	
Delivery	Cost	835	3,132		1355.94		1,355	
	# of cases	958	851		1683		1,601	
	Branch	**Branch 1**	**Branch 2**	**Branch 3**	**Branch 6**	**Branch 7**	**Branch 4**	**Branch 5**
	# of cases	958.00	472.00	379.00	732.00	951.00	595.00	1006.00
	Allocation %	100%	55.46%	44.54%	43.49%	56.51%	37.16%	62.84%
	Allocated cost	**835.38**	**1737.06**	**1394.80**	**589.75**	**766.19**	**503.57**	**851.41**

Table 74: Delivery costs allocation to Hummy's branch in Mar. 2021

2. Comparison between TD-ABC and ABC model

2.1 Developing an ABC model

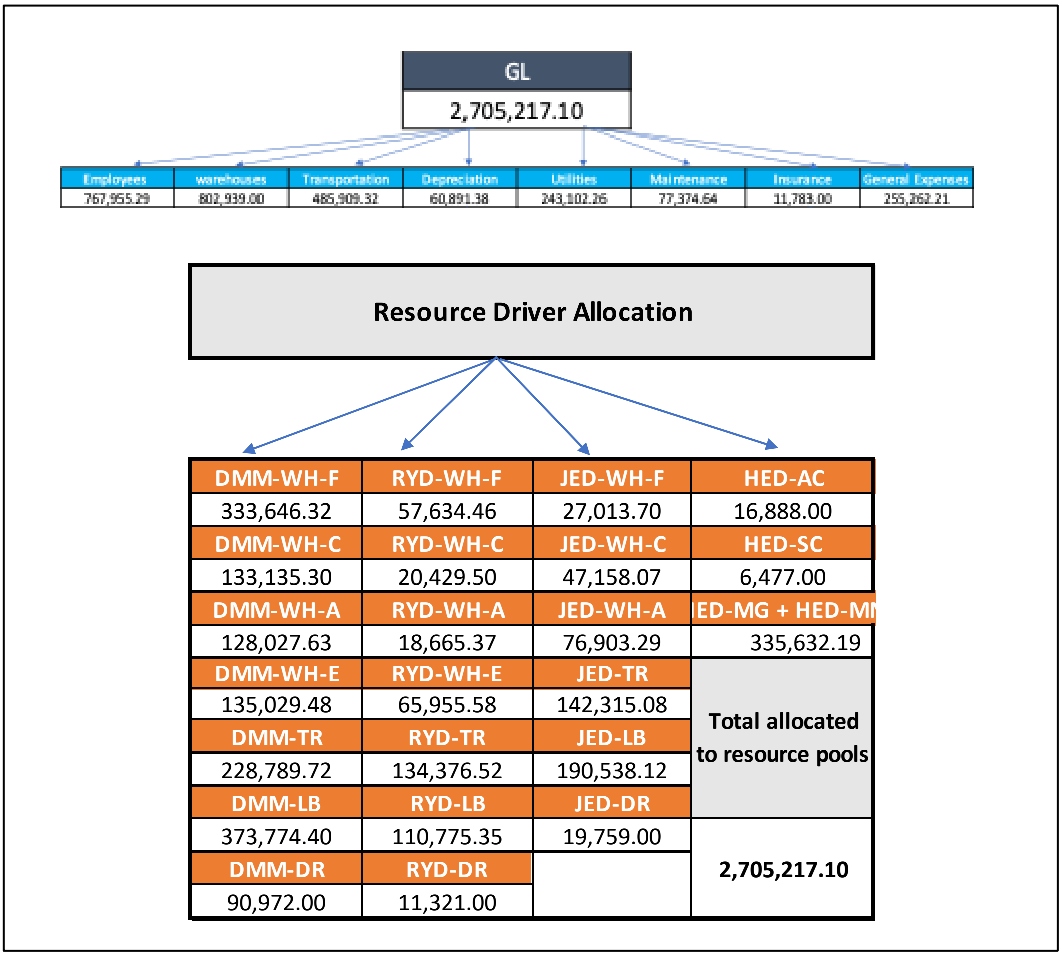

Figure 1: Allocation of expenses from GL to resource pools in Jan 2021 (ABC model)

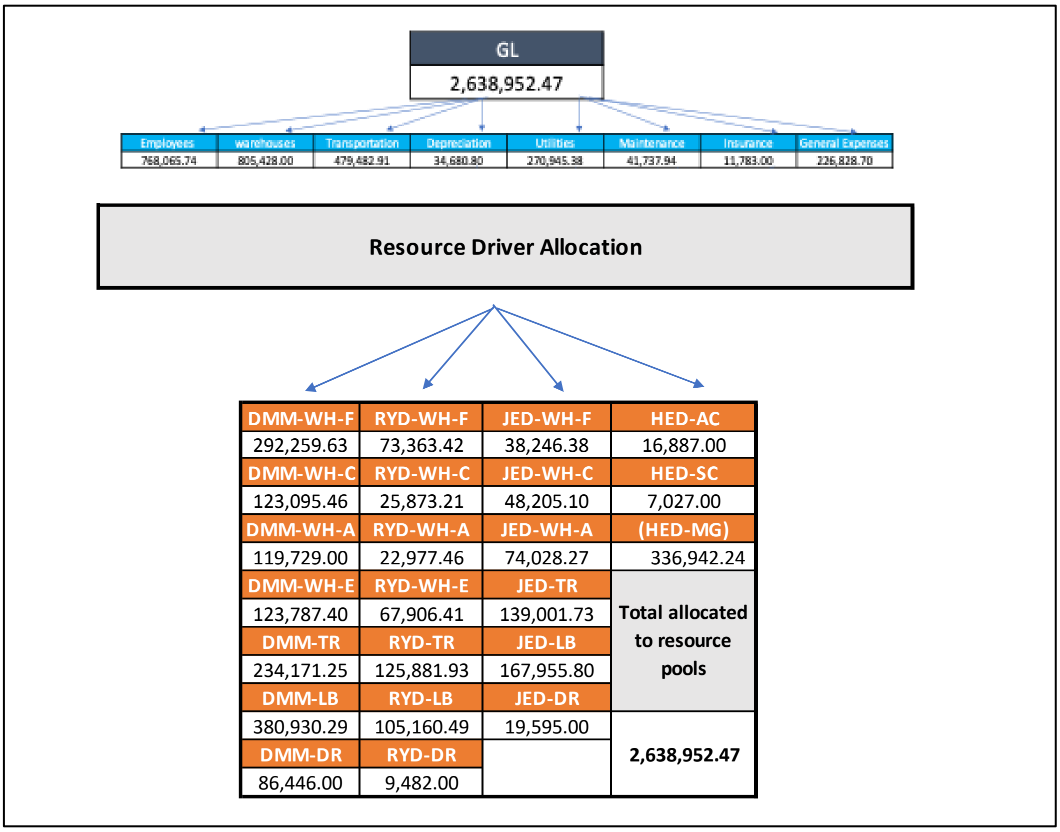

Figure 2: Allocation of expenses from GL to resource pools in Feb. 2021 (ABC model)

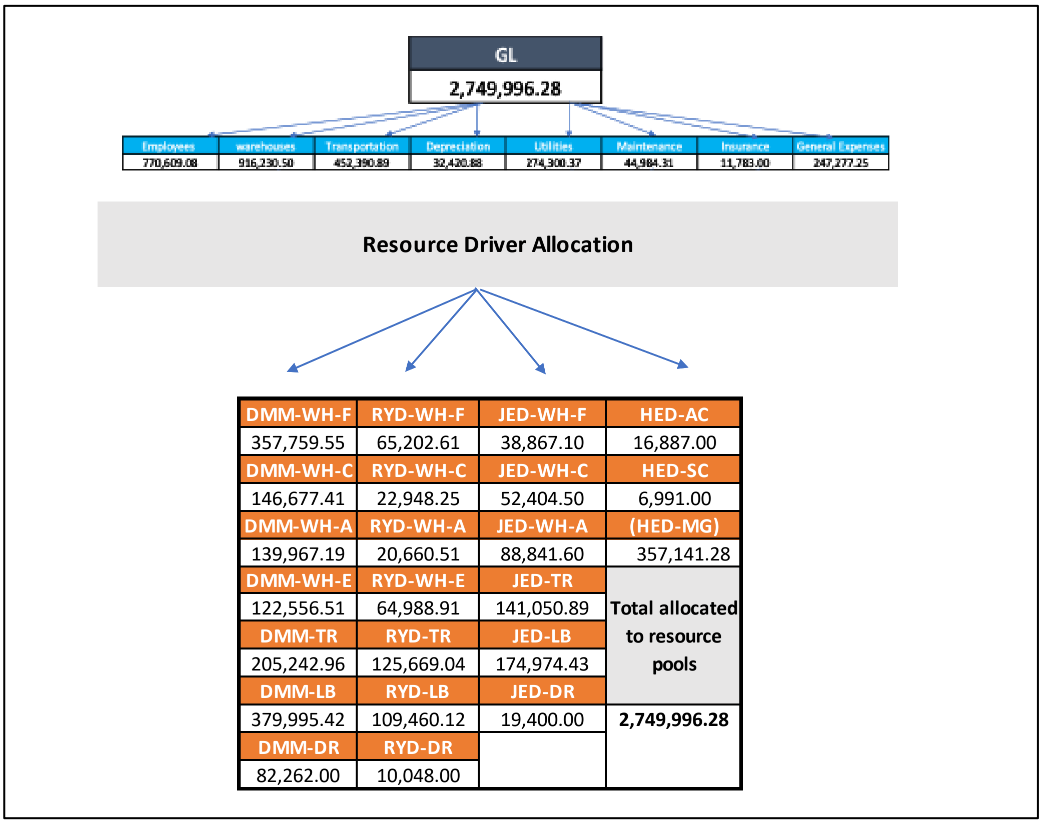

Figure 3: Allocation of expenses from GL to resource pools in Mar. 2021 (ABC model)

RP	RP Expenses (SAR)	Activity	Workload	Allocated cost (SAR)	Nr. Of transactions	Cost/transaction (SAR)
HED-SC	6477	Demand planning	39%	2526.03	5	505.2
		Procurement	6%	388.62	5	77.7
		Order processing	50%	3238.5	322	10.1
		Branch transfer	5%	323.85	15	21.6

Table 75: "HED-SC" activities costs in Jan. 2021 based on the ABC model

RP	RP Expenses (SAR)	Activity	Workload	Allocated cost (SAR)	Nr. Of transactions	Cost/transaction (SAR)
HED-SC	7,027.00	Demand planning	23%	1616.21	6	269.4
		Procurement	5%	351.35	4	87.8
		Order processing	68%	4778.36	310	15.4
		Branch transfer	4%	281.08	17	16.5

Table 76: "HED-SC" activities costs in Feb. 2021 based on the ABC model

RP	RP Expenses (SAR)	Activity	Workload	Allocated cost (SAR)	Nr. Of transactions	Cost/transaction (SAR)
HED-SC	6,991.00	Demand planning	21%	1468.11	7	209.7
		Procurement	5%	349.55	4	87.4
		Order processing	69%	4823.79	347	13.9
		Branch transfer	5%	349.55	21	16.6

Table 77: "HED-SC" activities costs in Mar. 2021 based on the ABC model

2.2 The comparison results

January 2021

RP	Activity	Cost per transaction (SAR)		Total cost (SAR)	
		ABC	TD-ABC	ABC	TD-ABC
HED-SC	Demand planning	505.206	125.86	2526.03	629.3
	Procurement	77.724	20.33	388.62	101.645
	Order processing	10.05745342	2.40	3238.5	772.1443
	Branch transfer	21.59	5.41	323.85	81.09367

Table 78: The comparison results between TD-ABC vs. ABC models for Hummy's operation costs in Jan. 2021

February 2021

RP	Activity	Cost per transaction (SAR)		Total cost (SAR)	
		ABC	TD-ABC	ABC	TD-ABC
HED-SC	Demand planning	269.3683333	136.71	1616.21	546.84
	Procurement	87.8375	26.61	351.35	159.63
	Order processing	15.41406452	2.59	4778.36	802.42
	Branch transfer	16.53411765	5.82	281.08	98.90

Table 79: The comparison results between TD-ABC vs. ABC models for Hummy's operation costs in Feb. 2021

Mar 2021

RP	Activity	Cost per transaction (SAR)		Total cost (SAR)	
		ABC	TD-ABC	ABC	TD-ABC
HED-SC	Demand planning	209.73	136.71	1468.11	546.84
	Procurement	87.3875	28.55	349.55	199.83
	Order processing	13.9014121	2.62	4823.79	907.56
	Branch transfer	16.6452381	5.79	349.55	121.62

Table 80: The comparison results between TD-ABC vs. ABC models for Hummy's operation costs in Mar. 2021

3. The cost and profit reports under the TD-ABC methodology

2-5500 CRAVI				
Group				
	Jan (SAR)	Feb (SAR)	Mar (SAR)	Total (SAR)
SALES	0.00	0.00	0.00	0.00
COST OF SALES	0.00	0.00	0.00	0.00
GROSS PROFIT	0.00	0.00	0.00	0.00
Operating cost:				
Demand planning cost	0.00	0.00	0.00	0.00
Prodcurement cost	0.00	0.00	0.00	0.00
Receiving shipment cost	0.00	0.00	0.00	0.00
Warehousing cost	28,740.91	30,173.19	38,119.78	97,033.88
Costing cost	0.00	0.00	0.00	0.00
Claims management cost	0.00	0.00	0.00	0.00
Branch Transfer cost	0.00	0.00	0.00	0.00
Order processing cost	0.00	0.00	0.00	0.00
Picking and loading cost	0.00	0.00	0.00	0.00
Delivery cost	0.00	0.00	0.00	0.00
Invoicing cost	0.00	0.00	0.00	0.00
Total operating cost	28,740.91	30,173.19	38,119.78	97,033.88
Operating cost % of sales	-	-	-	-
Indirect cost	16,781.61	16,847.11	17,857.06	51,485.78
Net profit	-45,522.52	-47,020.30	-55,976.84	-148,519.66
Net profit %	-	-	-	-

Table 81: Group Customer profitability in Q1-2021 according to the TD-ABC model

Branch 1				
	Jan (SAR)	Feb (SAR)	Mar (SAR)	Total (SAR)
SALES	212,474.00	192,636.00	236,801.00	641,911.00

COST OF SALES	-187,110.48	-169,839.29	-210,536.11	-567,485.88
GROSS PROFIT	25,363.52	22,796.71	26,264.89	74,425.12
Operating cost:				
Demand Planning	110.00	82.91	91.40	284.31
Procurement	29.50	26.05	28.72	84.27
Receiving shipments	274.72	449.77	93.35	817.84
Costing	15.20	10.22	15.20	40.62
Claims management	6.34	5.60	12.46	24.39
Branch Transfer	348.74	343.91	203.92	896.57
Delivery	824.94	720.79	835.38	2,381.11
Order processing	135.00	121.66	151.70	408.35
Invoicing	25.53	21.47	26.36	73.36
Picking and loading	4,453.08	3,986.18	4,942.52	13,381.78
Warehousing	1,197.49	1,161.50	1,490.90	3,849.89
Total operating cost	7,420.53	6,930.05	7,891.90	22,242.48
Operating cost % of sales	-	-	-	-
Indirect cost	0.00	0.00	0.00	0.00
Net profit	17,942.99	15,866.66	18,372.99	52,182.64
Net profit %	0.08	0.08	0.08	0.08

Table 82: "Branch 1" profitability in Q1-2021 according to the TD-ABC model

Branch 2				
	Jan (SAR)	**Feb (SAR)**	**Mar (SAR)**	**Total (SAR)**
SALES	112,111.00	97,597.00	114,545.05	324,253.05
COST OF SALES	-98,919.95	-86,678.14	-101,488.15	-287,086.24
GROSS PROFIT	13,191.05	10,918.86	13,056.90	37,166.81
Operating cost:				
Demand Planning	45.40	40.57	44.13	130.10
Procurement	12.12	12.75	13.86	38.73
Receiving shipments	112.83	220.10	45.07	378.00
Costing	6.20	5.00	6.20	17.40
Claims management	2.60	2.74	6.01	11.36
Branch Transfer	143.23	168.30	98.44	409.97
Delivery	1,478.35	1,821.99	1,737.06	5,037.41
Order processing	55.60	59.53	73.23	188.37
Invoicing	10.49	10.51	12.72	33.72
Picking and loading	3,203.10	2,812.21	3,742.26	9,757.56
Warehousing	573.40	478.42	631.20	1,683.02
Total operating cost	5,643.32	5,632.11	6,410.19	17,685.62
Operating cost % of sales	-	-	-	-

Indirect cost	0.00	0.00	0.00	0.00
Net profit	7,547.73	5,286.75	6,646.71	19,481.19
Net profit %	0.07	0.05	0.06	0.06

Table 83: "Branch 2" profitability in Q1-2021 according to the TD-ABC model

Branch 3				
	Jan (SAR)	**Feb (SAR)**	**Mar (SAR)**	**Total (SAR)**
SALES	95,658.00	42,083.00	92,741.33	230,482.33
COST OF SALES	-84,401.56	-37,327.95	-82,186.99	-203,916.50
GROSS PROFIT	11,256.44	4,755.05	10,554.34	26,565.83
Operating cost:				
Demand Planning	40.00	28.22	34.67	102.89
Procurement	10.54	8.87	10.89	30.30
Receiving shipments	98.11	153.11	35.41	286.64
Costing	5.40	3.48	5.40	14.28
Claims management	2.26	1.91	4.72	8.89
Branch Transfer	124.55	117.08	77.35	318.97
Delivery	1,221.74	812.75	1,394.80	3,429.29
Order processing	47.96	41.42	57.54	146.91
Invoicing	9.57	7.31	10.00	26.88
Picking and loading	2,647.10	1,254.46	3,004.90	6,906.47
Warehousing	547.48	173.44	498.34	1,219.27
Total operating cost	4,754.72	2,602.05	5,134.03	12,490.80
Operating cost % of sales	-	-	-	-
Indirect cost	0.00	0.00	0.00	0.00
Net profit	6,501.72	2,153.00	5,420.31	14,075.03
Net profit %	0.07	0.05	0.06	0.06

Table 84: "Branch 3" profitability in Q1-2021 according to the TD-ABC model

Branch 4				
	Jan (SAR)	**Feb (SAR)**	**Mar (SAR)**	**Total (SAR)**
SALES	159,681.50	111,396.00	138,773.00	409,850.50
COST OF SALES	-140,808.72	-98,301.31	-122,401.93	-361,511.96
GROSS PROFIT	18,872.78	13,094.69	16,371.07	48,338.54
Operating cost:				
Demand Planning	109.44	98.78	92.98	301.21
Procurement	29.50	31.04	29.21	89.75
Receiving shipments	274.72	535.89	94.96	905.57
Costing	15.12	12.17	15.12	42.41

Claims management	6.34	6.67	12.67	25.68
Branch Transfer	348.74	409.77	207.44	965.94
Delivery	562.65	467.02	503.57	1,533.24
Order processing	135.00	144.95	154.31	434.26
Invoicing	25.53	25.58	26.81	77.92
Picking and loading	3,735.86	1,902.97	3,196.93	8,835.75
Warehousing	782.43	468.15	499.09	1,749.68
Total operating cost	6,025.33	4,102.99	4,833.09	14,961.41
Operating cost % of sales	-	-	-	-
Indirect cost	0.00	0.00	0.00	0.00
Net profit	12,847.45	8,991.70	11,537.98	33,377.13
Net profit %	0.08	0.08	0.08	0.08

Table 85:"Branch 4" profitability in Q1-2021 according to the TD-ABC model

Branch 5				
	Jan (SAR)	**Feb (SAR)**	**Mar (SAR)**	**Total (SAR)**
SALES	186,913.00	183,996.67	243,425.83	614,335.50
COST OF SALES	-164,756.54	-162,463.45	-214,597.04	-541,817.03
GROSS PROFIT	22,156.46	21,533.22	28,828.79	72,518.47
Operating cost:				
Demand Planning	109.44	97.02	96.13	302.59
Procurement	29.50	30.48	30.20	90.19
Receiving shipments	274.72	526.32	98.18	899.22
Costing	15.20	11.96	15.20	42.36
Claims management	6.34	6.55	13.10	25.99
Branch Transfer	348.74	402.45	214.47	965.65
Delivery	662.85	747.42	851.41	2,261.68
Order processing	134.80	142.36	159.54	436.71
Invoicing	25.53	25.12	27.72	78.37
Picking and loading	4,401.11	3,045.52	5,405.23	12,851.87
Warehousing	1,014.34	1,112.75	1,426.96	3,554.05
Total operating cost	7,022.57	6,147.97	8,338.14	21,508.68
Operating cost % of sales	-	-	-	-
Indirect cost	0.00	0.00	0.00	0.00
Net profit	15,133.89	15,385.25	20,490.65	51,009.79
Net profit %	0.08	0.08	0.08	0.08

Table 86: "Branch 5" profitability in Q1-2021 according to the TD-ABC model

Branch 6				
	Jan (SAR)	**Feb (SAR)**	**Mar (SAR)**	**Total (SAR)**

SALES	135,555.50	146,672.16	172,937.17	455,164.83
COST OF SALES	-119,510.76	-129,530.82	-152,486.12	-401,527.70
GROSS PROFIT	16,044.74	17,141.34	20,451.05	53,637.13
Operating cost:				
Demand Planning	107.49	95.26	94.55	297.30
Procurement	28.97	29.93	29.71	88.61
Receiving shipments	269.81	516.75	96.57	883.14
Costing	14.90	11.74	14.90	41.54
Claims management	6.22	6.43	12.89	25.54
Branch Transfer	342.51	395.13	210.95	948.59
Delivery	524.60	551.42	589.75	1,665.77
Order processing	131.89	139.78	156.93	428.59
Invoicing	25.08	24.66	27.26	77.01
Picking and loading	3,194.31	2,468.40	3,933.03	9,595.74
Warehousing	505.81	652.69	773.94	1,932.44
Total operating cost	5,151.59	4,892.19	5,940.49	15,984.27
Operating cost % of sales	-	-	-	-
Indirect cost	0.00	0.00	0.00	0.00
Net profit	10,893.15	12,249.15	14,510.56	37,652.86
Net profit %	0.08	0.08	0.08	0.08

Table 87:"Branch 6" profitability in Q1-2021 according to the TD-ABC model

Branch 7				
	Jan (SAR)	**Feb (SAR)**	**Mar (SAR)**	**Total (SAR)**
SALES	188,075.00	185,611.34	228,134.33	601,820.67
COST OF SALES	- 165,761.06	-163,915.06	-201,242.20	-530,918.32
GROSS PROFIT	22,313.94	21,696.28	26,892.13	70,902.35
Operating cost:				
Demand Planning	107.49	104.08	92.98	304.54
Procurement	28.97	32.70	29.21	90.89
Receiving shipments	269.81	564.60	94.96	929.38
Costing	14.90	12.83	14.90	42.63
Claims management	6.22	7.03	12.67	25.92
Branch Transfer	342.51	431.72	207.44	981.66
Delivery	715.11	680.35	766.19	2,161.65
Order processing	131.89	152.72	154.31	438.92
Invoicing	25.08	26.95	26.81	78.84
Picking and loading	4,354.38	3,045.52	5,109.72	12,509.62
Warehousing	864.58	892.83	1,191.46	2,948.87
Total operating cost	6,860.94	5,951.33	7,700.65	20,512.92

Operating cost % of sales	-	-	-	-
Indirect cost	0.00	0.00	0.00	0.00
Net profit	15,453.00	15,744.95	19,191.48	50,389.43
Net profit %	0.08	0.08	0.08	0.08

Table 88: "Branch 7" profitability in Q1-2021 according to the TD-ABC model

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