A COMPARATIVE STUDY OF ACTIVITY-BASED COSTING (ABC) AND TIME-DRIVEN ACTIVITY-BASED COSTING (TDABC) ON COST ACCOUNTING

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ABSTRAK

Di dalam setiap persaingan perniagaan yang besar, adalah penting bagi syarikat untuk memasukkan anggaran kos yang tepat untuk menentukan harga terbaik bagi produk untuk mendapatkan keuntungan. Menjelang 1980-an, *Traditional Cost Accounting* (TCA) tidak lagi mencerminkan realiti ekonomi semasa disebabkan oleh maklumat yang menyimpang tentang keuntungan pesanan, produk dan pelanggan mereka. Di samping itu, *Activity-based Costing* (ABC) adalah kaedah kos yang asalnya dibangunkan untuk mengatasi kekurangan kaedah TCA dalam era kerumitan dan kepelbagaian produk yang semakin pesat berkembang. Walau bagaimanapun, ia tidak diterima secara umumnya kerana ia mengabaikan potensi keupayaan yang tidak digunakan di mana potensi itu akan memberi manfaat kepada ramalan prestasi sesebuah syarikat. Tambahan pula, journal semasa yang diterbitkan tidak menyatakan dengan jelas mengenai kadar kos kapasiti, kapasiti praktikal dan persamaan masa. Objektif kerja ini adalah untuk membandingkan kelebihan ABC dan *Time-driven Activity-based Costing* (TDABC) yang didorong oleh masa dengan menganalisis ciri-ciri ke arah kelestarian kos. Kerja ini bermula dengan mengumpul data di industri elektronik dan elektrik yang terletak di Pahang. Produk yang dipilih adalah induktor magnet. ABC memberi tumpuan kepada kos yang wujud dalam produk berasaskan aktiviti untuk menghasilkan, mengedarkan atau menyokong produk yang berkenaan. TDABC menggunakan persamaan masa dan kadar kos kapasiti untuk mengukur kapasiti yang tidak digunakan. Melalui kaedah ABC, kerja ini berjaya mengumpulkan masa yang digunakan oleh operator untuk menyelesaikan tugas yang diberikan. Masa terbesar yang digunakan oleh operator adalah pada aktiviti *epoxy application* iaitu 43.89% dan masa terkecil ialah 0.63% pada aktiviti *oven curing*. Kapasiti kos tertinggi ialah aktiviti *epoxy application* dengan kos MYR 1,665,729.98 dan jumlah bahan yang digunakan dipilih sebagai pemandu kos. Jika kuantiti permintaan produk meningkat sebanyak 10%, jumlah kos pengeluaran diramalkan adalah MYR 4,260,115.20 manakala kos produk seunit diramalkan sebanyak MYR 0.81. Melalui kaedah TDABC, kerja ini mendapat maklumat mengenai kapasiti pengendali praktikal iaitu 123,600 minit. Selain itu, kadar kos kapasiti aktiviti *winding* adalah MYR 2.53 dan persamaan masa adalah 0.12 χ_1 dengan χ_1 sebagai pembolehubah jumlah bahan mentah sebanyak 8,697.6 kilogram. Semua aktiviti dianalisis dan dikategorikan dalam 3 kategori iaitu optimistik, pertengahan dan pesimistik. Terdapat 7 sub-aktiviti di bawah kategori optimistik, 6 sub-aktiviti di bawah pertengahan dan 4 sub-aktiviti di bawah pesimistik. Kerja penyelidikan yang telah dijalankan di industri dengan mengimplimentasikan kaedah ABC dan TDABC seterusnya membuat perbandingan antara kedua kaedah ini dan menyimpulkan bahawa TDABC adalah kaedah yang mempunyai penentuan harga pemandu yang objektif, meyingkatkan proses yang memakan masa, membolehkan pemandu kos yang banyak dan dapat meramalkan dan merancang menggunakan analisis penggunaan kapasiti. Justeru, pihak industri akan mendapat kebaikan daripada implementasi kaedah TDABC dalam proses membuat keputusan.

ABSTRACT

In any business competition, it is important for the company to incorporate an accurate cost estimation to decide the best price for products to gain profits. By the 1980s, Traditional Cost Accounting (TCA) is no longer reflecting the current economic reality due to distorted information about the profitability of the company's orders, products, and customers. In addition, Activity-based Costing (ABC) is a costing method originally developed to overcome the shortcoming of TCA method in the era of rapidly increasing product complexity and diversification. However, it is not universally accepted because it ignores the potential for unused capacity which will be beneficial for forecasting. Nevertheless, the current published work does not clearly state of capacity cost rate, practical capacity and time equation. The aim of this work is to compare the advantages of ABC and Time-driven Activity-based Costing (TDABC) by analyzing the features towards costing sustainment. The work begins by collecting data at electrical and electronic industry located at Pahang and the product selected is a magnetic inductor. ABC focuses on the costs inherent in the activity-based products to produce, distribute or support the products concerned. TDABC uses time equation and capacity cost rate to measure the unused capacity with respect to the time and cost. Through ABC method, this work successfully gathered the time allocated by operator to complete the task given. The largest time allocated by operator is at epoxy application activity which is 43.89% and the smallest is 0.63% at oven curing. The highest amount of cost of capacity is epoxy application activity with cost of MYR 1,665,729.98 and the amount of material used is selected as the cost driver. As the demand quantity of the product is increase by 10%, the total cost of production is predicted to be MYR 4,260,115.20 while the unit product cost is forecast at MYR 0.81. Through TDABC method, this work gains information on practical capacity of operator which is 123,600 minutes. Moreover, the capacity cost rate for winding activity is MYR 2.53 and the time equation is $0.12\chi_1$ with χ_1 as variable of amount of raw material of 8,697.6 kilograms. All sub-activities are analyzed and categorized in 3 categories which are optimistic, most likely and pessimistic. There are 7 sub-activities under optimistic category, 6 sub-activities under most likely and 4 sub-activities under pessimistic. In conclusion, by implementing and comparing of ABC and TDABC at the company, this work proves TDABC is a method with objective cost driver determination, removes time consuming process, have multiple cost drivers and able to forecast and planning using analysis of capacity utilization. Thus, TDABC can improve the company costing structure by using the advantages of TDABC in order to gain detailed decision-making process.

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Tt	Time needed to perform an activity
β_i	Estimated time to perform the incremental activity
β_0	Standard time to perform the basic activity
$	Dollar currency sign
χ_i	Quantity of the incremental activity

LIST OF ABBREVIATIONS

ABC	Activity-based Costing
BOM	Bill of Material
LOH	Labor and Overhead
MHU	Material Handling Unit
MTS	Mahalanobis-Taguchi System
TCA	Traditional Cost Accounting
TDABC	Time-driven Activity-based Costing
US	United State
VBC	Volume-based Costing
VMI	Visual Mechanical Inspection

CHAPTER 1

INTRODUCTION

1.1 Research background

Cost accounting is a conscious and balanced procedure for collecting costs and relating such costs to specific products or departments for effective management action. Cost accounting establishes budgets, standard costs and actual costs. It is also a set of procedures used in refining raw data into usable information for management decision making, for ascertainment of cost of products and services and its profitability.

Kaplan and Johnson, (1987) claimed that management accounting had not changed since the early 20th century. It had lost its applicability in delivering decision-making information. Traditional cost accounting is not conceptually prepared to operate efficiency to support a growing business anymore. Increased demand pressure from customers, coupled with increased competition among manufacturers over the past two decades, formed the basis for the development of cost and accounting management.

In the mid-1980s, Activity-based Costing (ABC) has emerged in response to competitive challenges and in pursuing their overall strategic goals (Kaplan et al., 1992). However studies shows that ABC adoption in company remains low (Esmalifalak et al., 2015). Unfortunately, the adopting process of ABC had significant issues (Allain & Laurin, 2018) (Fito et al., 2018). ABC is considered as an obsolete method due to the time-consuming and costly method of measuring operation costs by interviews. The complexity of gathering, preserving, sorting and reporting and upgrading of information were some of the problems occurred (Kaplan & Anderson, 2007).

Therefore, a new method called Time-driven Activity-based Costing, known by the initials TDABC is developed. It is developed further from the ABC in a way that time is used as the main cost driver (Da Silva Medeiros et al., 2017). The ability of TDABC to grasp the needed metrics causes it to be a valuable costing method. As mention by Barros and Da Costa Ferreira (2017), TDABC model is practical and ideal for manufacturing environments. It is capable of handling system variation as well.

Moreover, one of the ways for companies to remain profitable, the system used need to identify waste, recognize efficiency and develop improvement on unused capacity information. The impact of profitability and cost management affects all processes of management and is a crucial element of an overall management system for a business performance. Assessing the efficiency and effectiveness of a particular service or product requires combining product cost information with outcome measures to attain cost-effective ratios and other efficiency measures.

1.2 Problem statement

The traditional cost system designed seventy-five years earlier is no longer reflected the current economic reality. It is not compatible enough as the environment and technology has been evolved with rapid complexities and activities scope. Thus, the traditional costing model are likely to result in distorted product costs (Phan et al., 2018).

ABC consist of four elements which are activity map, activity analysis, assign cost categories and cost drivers. A work by Sembiring et al. (2018) took place in a manufacturing environment but the work did not emphasize on the element of cost driver. Cost drivers give out information for decision- making process in a company. Eventually, ABC is able forecast product cost according to demand quantity. An electrical and electronic production company is able to generate specific product cost by using existing costing structure. Product cost is generated through accumulation of labor and overhead (LOH) and bill of material (BOM) of the product. However, the cost drivers are not clearly justified in their final costing.

ABC is a costing method originally developed to overcome the shortcoming of Traditional Cost Accounting (TCA) method in the era of rapidly increasing product complexity and diversification (Van Dyk et al., 2017). The method provides transparency in the costing structure of the activities as well as information for competitive price strategy using cost driver rates and provides relevant information for the decision-making process in various domains. However, it was not universally accepted because the produced model theoretically incorrect when it ignored the potential for unused capacity which will be beneficial for forecasting (Kaplan & Anderson, 2007). Unused capacity information gives out the company knowledge on productivity and efficiency. On the other hand, TDABC maximizes the role of capacity cost rate and time equations to generate unused capacity information which can be used in forecasting.

A work by Zhuang and Chang (2017) compared the model of ABC and TDABC integrated with mixed integer programming to gain information on profits and capacity utilization of the resources. The work emphasizes on the strength of ABC on determination cost drivers, while the strength of TDABC is capacity utilization in terms of cost of resources. However, the work did not clearly describe the evidence for the both method. Therefore, this work supports the paper by conducting comparison of costing structure based on costing sustainment features.

1.3 Research questions

The research questions are as follows:

1. How does ABC identify the cost driver?
2. How does TDABC appraise the role of capacity cost rate and time equations?
3. How does ABC costing structure differ from TDABC costing structure?

1.4 Objectives

The research objectives are as follows:

1. To identify the cost driver of ABC for development of the costing structure.
2. To appraise the role of capacity cost rate and time equation in TDABC.
3. To compare costing structure between ABC and TDABC by analysing the features toward costing sustainment.

1.5 Scope of study

In order to achieve the objectives, the following scopes of research are identified.

a) Throughout this research, product cost, time equation, practical capacity and capacity cost rate are studied and this work is focused on the process line only.

b) The product used in this study is a magnetic inductor.

c) The data collected from an electrical and electronic production company in Kuantan, Pahang. It is an innovative global electronics company supplying the automotive, medical devices, industrial and defence components applications.

1.6 Significant of research

The study proposed a comparative study of implementation of ABC and TDABC on a magnetic inductor process production. By implementing ABC, it highlights the benefits of ABC especially cost driver in the costing structure. By implementing TDABC, it appraises the role of capacity cost rate and time equation which eventually leads capacity utilization information that is definitely useful for forecasting in the future. Consequently, the industrial practitioner is able to identify which activity has more efficiency and the corporate management could plan a strategic business in the future.

1.7 Organisation of thesis

Chapter 1 describes the background of research, problem statement, objectives, scopes and significance of research.

Chapter 2 exposes ABC details with some definitions obtained from worldwide sources. Then, the concept of ABC with advantages and disadvantages is pointed out. The issue on ABC is narrowed down to five elements in the research gap. The chapter also provides details of TDABC together with a description of the concept. The advantages and disadvantages of TDABC are highlighted. The elements of TDABC are categorized into 6 categories and it emphasized forecasting as the gap to be discovered.

Chapter 3 describes in detail the research methodologies employed in the study and divides it into four phases. Phase 1 is hypothesis construction, phase 2 is data collection, phase 3 is data analysis and phase 4 conclusion and recommendation.

Chapter 4 describes the implementation of ABC method into the production process. The manufacturing flow is analysed with cost of capacity of every workstation is gathered. The time allocated for each activity is collected through survey process. The cost driver of the process is determined and forecasting is generated by using the information of cost driver rate.

Chapter 5 continues the research work by implementing TDABC method into the production process. Once the cost of resources used is estimated, the work proceeds with practical capacity estimation and capacity cost rate calculation. Next, the highlight of TDABC method is carried out by generating the time equations and time variables. By using all of the information gathered, the capacity utilization data is obtained.

Chapter 6 compares of the elements between the ABC and TDABC systems. The elements are compared by their differences by presenting examples from works done in previous chapters.

Chapter 7 presents the conclusions for the research work and divides it into three sections. It starts with the research findings by fulfilment of research objectives, followed by concluding comparative study of ABC and TDABC and discusses possible future research that can be done by other researchers.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discuss the related previous research towards Activity-based Costing (ABC) and Time-driven Activity-based Costing (TDABC). The definitions and concepts are pointed out as well as the advantages and disadvantages. The application of both ABC and TDABC are both included and research gap is concluded in this chapter.

2.2 Factors influencing costing in industry

The selection method to be applied to certain industry or sector is influenced by many factors such as timing of change, market conditions, financial performance and managerial initiatives. The same costing model used traditionally may not be compatible enough as the environment and technology has been evolved. Thus, the traditional costing model are likely to result in distorted product costs (Phan et al., 2018).

In addition, every sector of industry is different and unique which makes finding one costing model that suits all types of sectors challenging. In manufacturing sector, the introduction of high technology machineries leads to changes of the production cost structure. Therefore, towards developing modern technology, there should be awareness to implement new innovations of costing system. By now, there are activity-based costing methods available for instance, ABC and TDABC method.

2.3 Definitions of Activity-based Costing (ABC) from various sectors

ABC is a method to assist managers makes better decisions about product design, pricing, marketing, and mix, and encourages continual operating improvements (Tsai et al., 2016). Once identified this capacity can either be eliminated, reducing costs, or re-deployed, improving effectiveness (Greasley & Smith, 2017).

ABC is an accounting information system that identifies various activities that are carried out within an organization and collect fees on the basis and nature of existing and expansion of its activities. ABC focuses on the cost inherent in the activity based products to produce, distribute or support the products concerned (Sembiring et al., 2018). Moreover, ABC method provides accurate information with cost drivers during manufacturing process (Almeida & Cunha, 2017).

Furthermore, ABC is one of innovative management accounting techniques and it is an important cost management approach that encourages firms to gain efficiency, effectiveness, success, growth, survival, and sustainability (Ussahawanitchakit, 2017). ABC can help educational institutes acquire detailed costing data and discern possible hidden costs that they may have previously been unaware of (Sorros et al., 2017).

ABC is an activity analysis method developed to understand the indirect support costs of decision management or operations (Lu et al., 2017). ABC is a technique able to infer the cost measure associated to each activity, thus contributing to processes performance measurement (Cannavacciuolo et al., 2015).

Nevertheless, ABC is useful in providing organisations with more accurate product cost information, thereby facilitating decisions in relation to pricing, product mix, quality improvement, outsourcing, and product design and development (Tsai, et al., 2013). ABC is a well-known technique for accurately costing products and potentially providing cost data and management information to facilitate decision making well. ABC helps to accurately understand the allocation of resources through cost drivers (Ussahawanitchakit, 2017).

2.4 Implementation concept of ABC

There are numerous authors such as Suthummanon, et al. (2011), Greasley and Smith (2017) and Lu et al. (2017) had discussed the ABC concept. Figure 2.1 shown a work by Suthummanon et al. (2011) where it focuses on four main steps of ABC: (1) identifying the activities consuming the organization's resources, (2) determining the organization's key activities and business processes, (3) estimating the cost of the activities and business processes that are performed, and (4) determining the amount of activities required for the development of an organization's product.

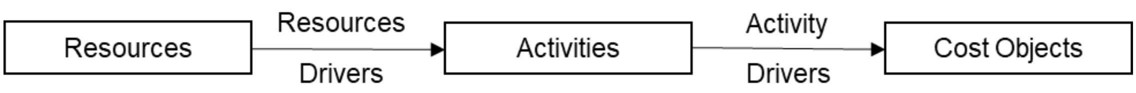

Figure 2.1 Activity-based Costing cost flow

Source: Suthummanon et al. (2011)

Greasley and Smith (2017) considered the communications centre from the perspective of each of the three drivers of cost in Figure 2.2. The cost driver relates primarily to the design efficiency of the activities within the call handler process of the communications centre. The resource driver relates primarily to staffing costs for personnel involved in the arrest process. The activity driver relates to the timing and frequency of the different call types made to the communications centre.

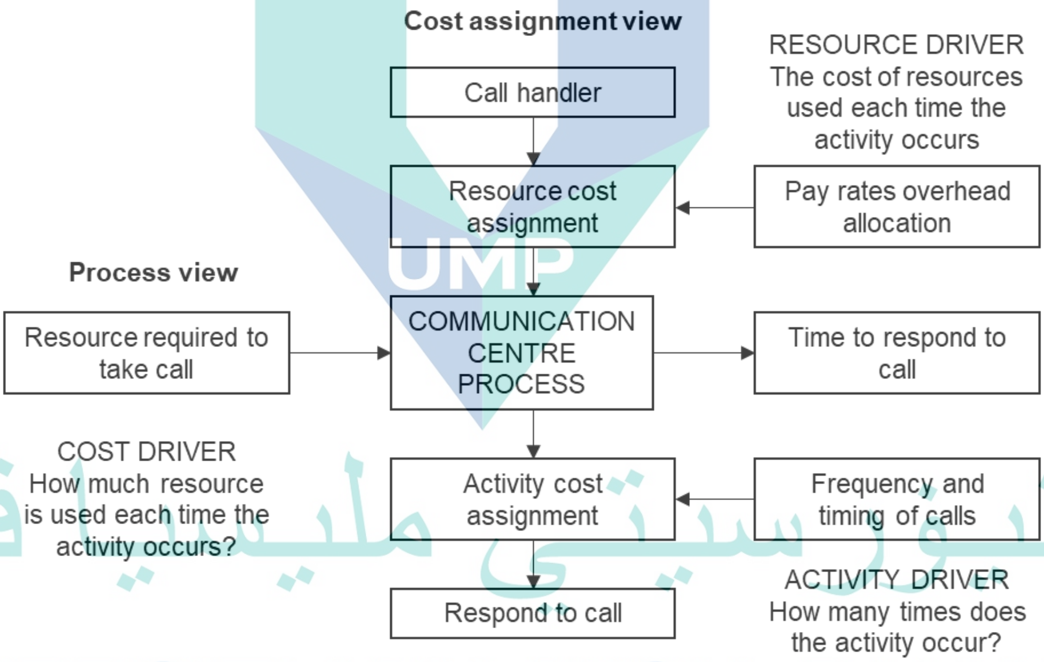

Figure 2.2 The ABC view of the communication centre process

Source: Greasley & Smith (2017)

In Figure 2.3, Lu et al. (2017) describe the steps on ABC in detail manner. Firstly, the goals of bicycle parts ABC system implementation are set up. The bicycle parts industry must define the main objective of the implementation of ABC, and then calculate the accurate product cost. Secondly, the ABC work team is organized. Team members should have diverse background and multiple professional perspectives in different departments of the company.

Thirdly, the bicycle parts manufacturing flow analysis is completed. Team members should interview senior managers and operators for manufacturing process and conversion activities. Next, the activity level is categorized. The conversion activities is divided into five activities categories for unit, batch, product, customer and facility level which is based on the frequency of resources consumed.

Next step is to select resource drivers. Resource driver are the causal factors which cause resources cost occur. All of resources must be involved such as indirect labours, facilities, utilities, and indirect resources cost incurred. These indirect costs allocate to resource pool based on resource drivers.

Then the resource pool is calculated. This step allocates the indirect cost to all of the resources pool based on resources drivers. The resources cost pool includes: machine cost, set-up cost, inspection and inventory cost, research and development cost, and facility cost, and so on. The resource centre of in-house parts sector establishes on department or division as an example in this paper.

Next step is to select the proper activity cost driver and calculate the cost driver rate. The proper cost driver needs to fit to the manufacturing process, such as inspection times, machine hours, set-up times, category of new product, and direct labour hours. The activity cost rate is calculated by dividing resources cost with consumption quantities of activity cost drivers. After that, the cost object is defined.

Subsequently, the ABC cost information database is established. It is for ensuring that the cost calculation approach can be applied to any process of bicycle parts and products industry feasibly and repeatedly.

After that, the cost object of bicycle parts and products is calculated. ABC cost information database is applied to calculate the cost object for parts and products. Lastly, the comparisons of Volume-based Costing (VBC) and ABC is explored and explained for the cost difference, and generating subsequent impact.

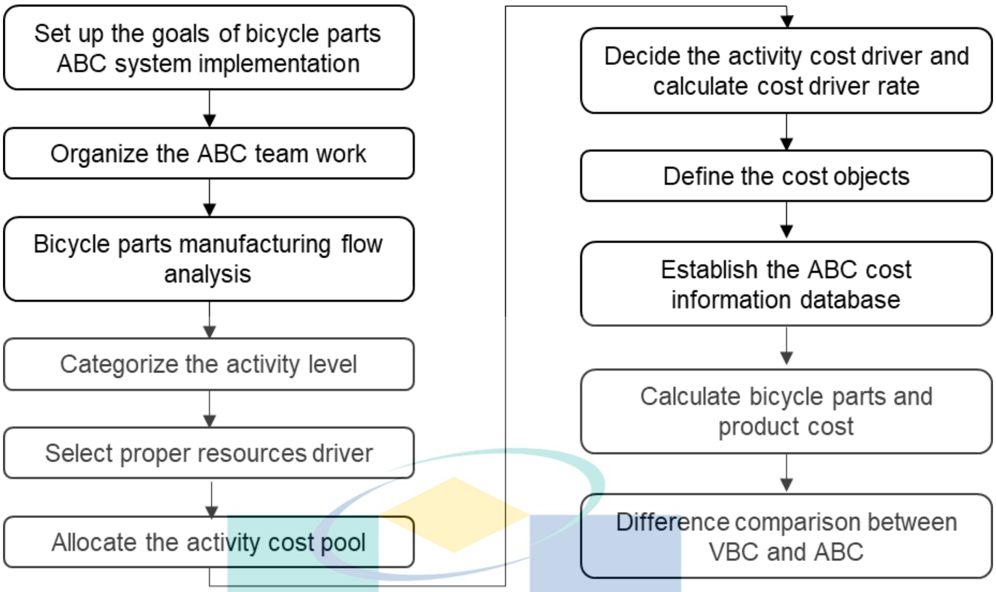

Figure 2.3 Implementation process of ABC system

Source: Lu et al. (2017)

While Chouhan et al. (2017) stated ABC is a two-stage allocation process, first costs are traced to activity and then to product. In Figure 2.4, it emphasizes on the need to obtain a better understanding of the behaviour of the overhead cost and thus to ascertain its causes and its relation to the product.

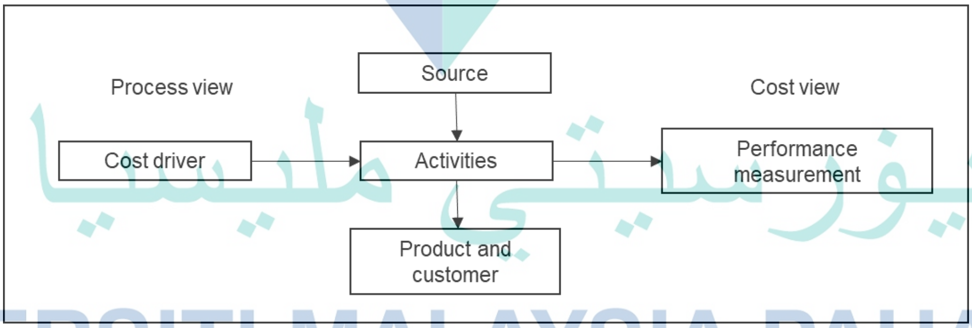

Figure 2.4 Activity-based costing model

Source: Chouhan et al. (2017)

2.5 Advantages and disadvantages of ABC

Sembiring et al. (2018) reported that cost of goods manufactured of Crude Palm Oil calculated using ABC method showed cheaper result compared with that calculated using the traditional method. Furthermore, as compared to traditional costing methods, the ABC method ensures accurate cost-benefit analysis and performance improvement.

Institutes that can identify costly services, give better results with regard to their efficiency in decision making (Sorros et al., 2017). ABC allows us to conceptualize expatriation as a process (Nowak & Linder, 2016). ABC system provides more accurate cost estimates rather than the traditional "order costing" methods that use unit-level costs which are variable in relation to change in service volume (Haroun, 2015).

The ABC system provide accurate information cost with multiple activity cost drivers and causal relationships between resources consumption and cost during manufacturing process (Lu et al., 2017). Once divided into direct and indirect costs, the ABC technique provides their allocation to the activities that generated them, and then, through appropriate cost drivers, provides their attribution to the investigated object in this case the ART treatment cycle (Cassettari et al., 2016). According to Yang et al. (2016), ABC provided an accurate and integrated cost computation, especially under conditions in which activities vary and in which the indirect costs represent a substantial proportion of the total costs.

Moreover, in industrial field, the integrated model can help transport infrastructure project managers accurately understand how to allocate resources and funding for energy-saving activities to each project, through appropriate cost drivers (Yang et al., 2016). In health care practice, ABC tool could be used for correct cost estimation, revenue estimation of profitability analysis, efficient resource allocation, and improved quality service provision. Hence, Adane et al. (2015) suggested that the hospital should adapt better costing methods rather than going simply with traditional methods of costing.

By having an established ABC-friendly environment, improvements at all levels of aggregation can be achieved (Hofmann & Bosshard, 2017). The use of the ABC system allowed study of the complete map of activities and, consequently, of the relationships that connect them (Martino et al., 2017). In actual fact from Ussahawanitchakit (2017), firms with successful activity-based costing implementation tend to have superior performance in long-term aspect and gain growth, survival and sustainability in highly dynamic competitive environments. As stated by Yang et al. (2016), the management technology of ABC can guide decision making and establish alternative priorities.

On the negative side, ABC has several disadvantages as well. According to Quinn et al. (2017) ABC appears to be a time consuming exercise, perception of high cost of ABC implementation and complex. ABC systems are often perceived as tools that, once implemented, can indeed simultaneously be used in controlling and enabling ways. However, when the cost system has to be used in an enabling way to support decision-making, attempts aimed at enhancing the flexibility of the system could generate technical difficulties (Allain & Laurin, 2018). The most common reasons for not considering ABC were the inherent difficulties with ABC design and implementation and the costs that might be incurred. The greatest barrier to implementing ABC was found to be its high cost of implementation, followed by the high cost of ABC consultancy and computer staff time. Difficulty in gathering data on cost drivers and difficulty in designing system drivers were also cited as barriers to implementation and use of ABC (Nassar et al., 2013).

2.6 Application of ABC in different sectors

ABC has been widely used in many different sectors to facilitate organization. Figure 2.5 shows the distribution of the application of ABC. The data are collected based on open accessed published papers from 2011-2018 as shown in Appendix A. The percentage of ABC in manufacturing is the highest which is at 38% while health care and transport and communication share the same percentage at 13% for the lowest application of ABC. Other sectors have 19% of application followed by management 17%. Based on the data above, it is clear that ABC method has been widely applied in manufacturing industry. Abu et al. (2017) estimated the cost of remanufactured crankshaft using ABC while Abu et al. (2018) identified the critical and non-critical variables during remanufacturing process using Mahalanobis-Taguchi System and simultaneously estimate the cost using ABC. Currently, Zheng and Abu (2019) applied the ABC as a method of cost estimation for the palm oil plantation.

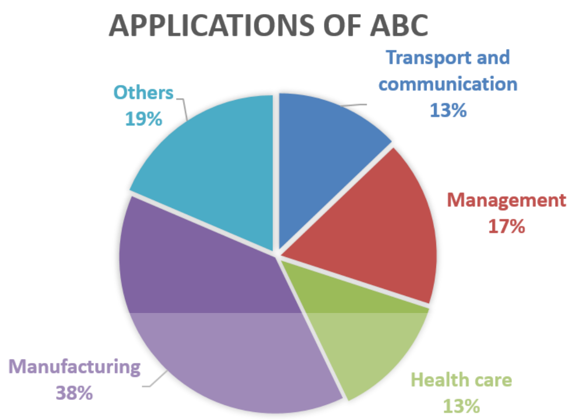

Figure 2.5 Applications of ABC

2.7 Research gap of ABC

In this study, ABC journals are considered and analysed. Those journals are published from 2011-2018 from different journal publications and only open accessed papers are considered. Appendix B shows summary of ABC journals.

According to Wouters and Stecher (2017) ABC has been classified into five topics. Figure 2.6 displays the percentage of ABC topics. The organizational and effectiveness of ABC and the usage of ABC in decision making are the most commonly addressed topics at 31% and 29% respectively. The list followed by dissemination of the method (23%), reviews and critical analysis (10%) and the least at 7% for adoption or implementation of ABC.

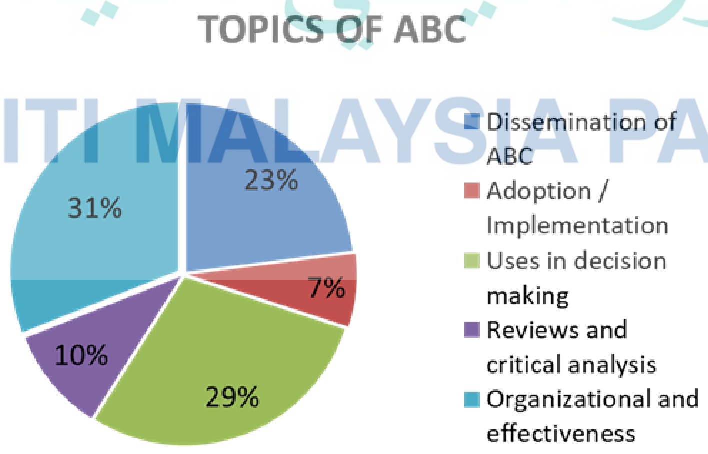

Figure 2.6 Topics of ABC in journals

This work focused on the adoption or implementation topic as it is the most suitable topic for this research scope. Table 2.1 shows six journals that discussed about adoption or implementation of ABC. All six journals are further discussed into the elements of ABC. The elements are activity map, activity analysis, categories of cost assigned and cost drivers.

By referring to Table 2.1, Sembiring et al. (2018) did not mention about cost drivers that gives the information for the decision making process. According to Almeida and Cunha (2017) the work on activity map was not highlighted. It is important to have every activities and sub-activities identified for the analysis. Same as work done by Alsmadi et al. (2014) the activity map is not mentioned in the steps of applying ABC. Moreover, activity analysis where activities are analysed for improvements to increase performance was not stated by Lu et al. (2017). The work done by Haroun (2015) did not emphasize on activity analysis which can be helpful for future improvement. The work by Ussahawanitchakit (2017) did not emphasize the activity map, activity analysis and cost drivers while it is crucial because to have effectiveness and efficiency, the activities and the drivers must be clearly defined and analysed.

Table 2.1 Elements of ABC

	Elements of ABC			
Author	**Activity map**	**Activity analysis**	**Assign cost categories**	**Cost drivers**
(Sembiring et al., 2018)	✓	✓	✓	×
(Almeida & Cunha, 2017)	×	✓	✓	✓
(Lu et al., 2017)	✓	×	✓	✓
(Ussahawanitchakit, 2017)	×	×	✓	×
(Haroun, 2015)	×	×	✓	✓
(Alsmadi et al., 2014)	×	✓	✓	✓

Therefore, this work intends to fill the gap found from previous works on activity map, activity analysis, assigning cost to categories and cost drivers. This work focuses on the elements of ABC by implementing the costing method at the company. The activity map and activity analysis would be clearly identified as well as assigning cost categories. Based on the identified activities, the cost drivers would be determined accordingly.

2.8 Definition of TDABC from various sectors

The Time-driven Activity-based Costing (TDABC) is a costing model that considers the time as the only inducer costing. Its purpose is to provide costs of activities with base in consume of time per activities (Da Silva Medeiros et al., 2017).

TDABC method has been developed from the traditional ABC method which requires significant processing in data collection and cost allocation (Pongwasit & Chompu-inwai, 2016). TDABC then simplifies the complex formulations for ABC. With TDABC, when there is any additional activity to be taken into account, the above time equation can be easily extended (Zhuang & Chang, 2017).

As stated by (Bauer-Nilsen et al., 2018), TDABC is a bottom-up approach that determines cost by estimating the cost of each resource and the time each resource is used during each activity involved over the full course of treatment of a patient's medical condition. This allows for better and more transparent estimates of the expenses incurred by providers in providing treatment.

TDABC is commonly used in manufacturing and other service industries to assign costs accurately (Keel et al., 2017). TDABC is a costing methodology that provides a granular view of costs which directly reflect resource use and duration. Thus providing actionable cost data to improve the healthcare delivery process (Yu et al., 2017).

2.9 Implementation concept of TDABC

TDABC skips the activity-definition stage. This approach avoids the costly, time consuming, and subjective activity-surveying task of conventional ABC. It uses time equation that directly and automatically assigns resource costs to the activities performed and transactions processed. Generally, TDABC requires two key parameters which are capacity cost rate and time required to perform activities. Both parameters can be estimated straightforwardly and objectively.

Figure 2.7 represents the flow of resource expenses up to the costing objects. The company does not cover the maintenance department, the sales departments or the transport area within the logistics and distribution department. The company is feasible for these areas, but does not yet have databases that allow them to be incorporated in the model. 16 processes were identified in the departments covered by this model. Nine of these comprised macro process of production, three in the macro process of logistics and four others in the macro processes of invoicing, export, purchasing and quality control.

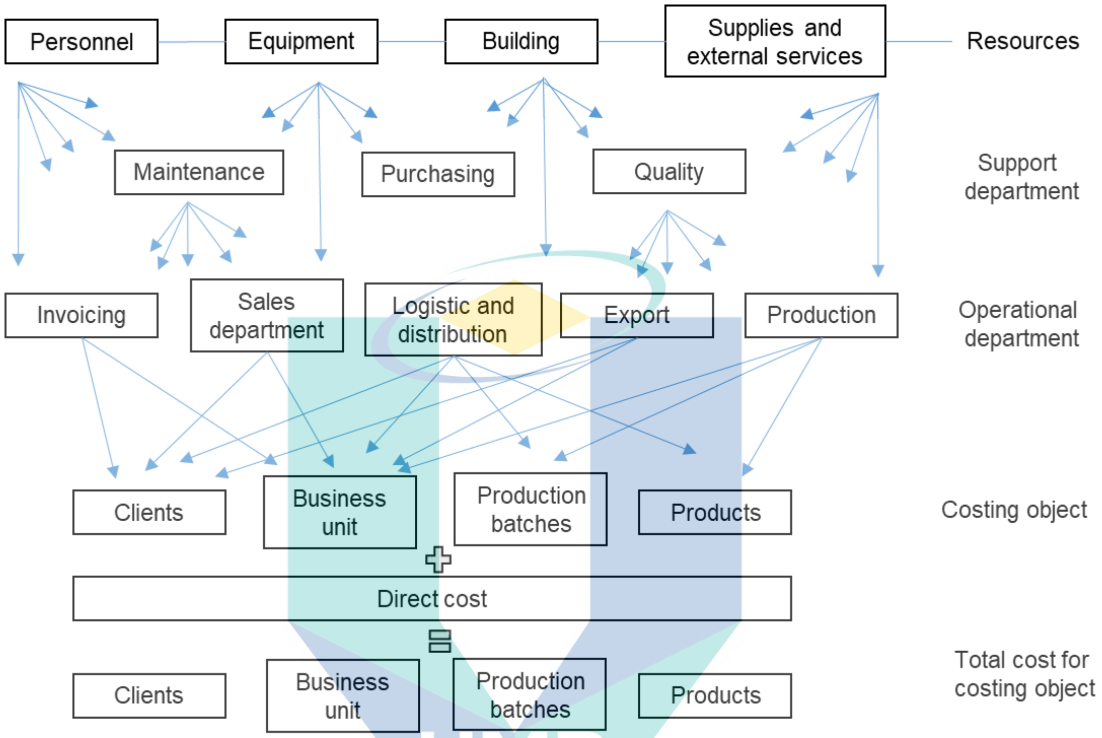

Figure 2.7 TDABC procedure

Source: Barros & Da Costa Ferreira (2017)

In brief for health care sector as in Figure 2.8, the TDABC entailed developing process maps to represent the steps of each component of treatment. It includes personnel, equipment, and consumable supplies involved in delivering care. To estimate facilities cost, there are several steps to be done. For example, estimating time required by interviewing personnel involved in patient care, estimating the costs of personnel, equipment and supplies according to salary data, equipment purchasing information, and direct discussion with medical centre administration. TDABC also estimate of the capacity cost rate for each staff member and equipment by calculate the total annual capacity of each resource and then divide the annual cost by the capacity. TDABC calculate the total cost by multiplying the capacity cost rate for each resource by time estimate for the process and adding any additional costs of consumable supplies (Bauer-Nilsen et al., 2018).

1. Identify phases of care for a hospital episode
2. Create process map of all direct interactions
3. Assign median time to complete each interaction
    a. Sources:
        i. Retrospective electronic time stamp data
        ii. Prospective observation data
        iii. Average estimates from personnel experts
4. Calculate capacity cost rates (cost/min) for each personnel type
5. Apply any weights or adjustments to the model
6. Determine cost of each process and phase of care
        a. Multiple capacity cost rates and durations for each process
7. Sum all costs (personnel and consumables) to obtain total costs

Figure 2.8 Outline of 7 steps of TDABC in hospital

Source: Yu et al. (2017)

Referring to Figure 2.9, production activities (activity centres /sub-activities) have to be identified. Then the estimation of the costs of all resources used and the acceptable capacity are required for the capacity cost rate calculation. To calculate the production costs, time equations have to be created for activity centre. After the estimated time for each activity is determined, and the capacity demand of each activity centre also calculated. Finally, the cost per product unit is derived.

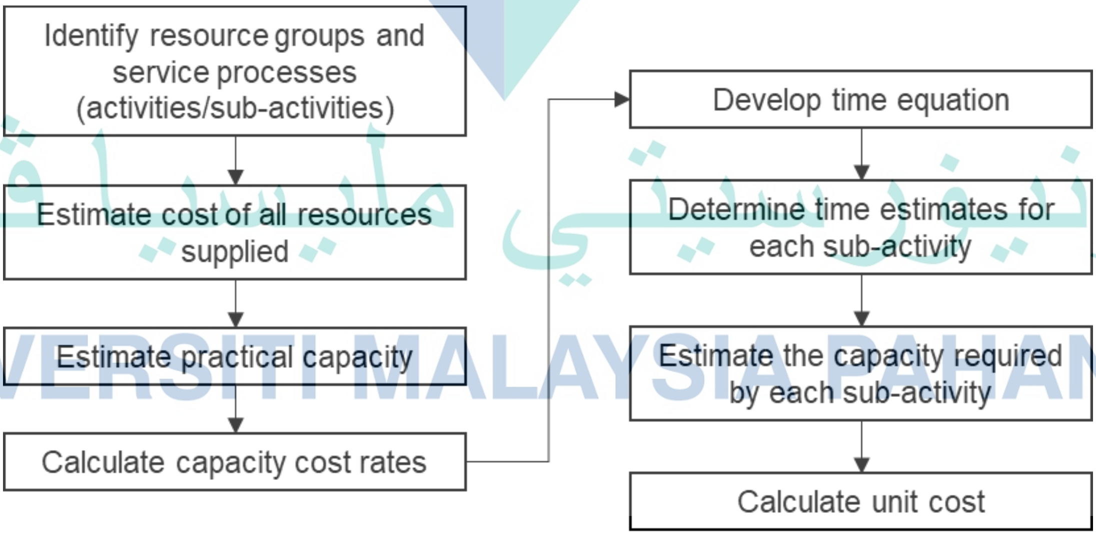

Figure 2.9 Applying TDABC process

Source: Pongwasit & Chompu-inwai (2016)

2.10 Advantages and disadvantages of TDABC

The TDABC approach overcame ABC difficulties and had advantages. The advantage over ABC is in simplifying the costing process. The TDABC eliminates the costly process of work, in order to collect information on the cost allocation of resources and activities before directing it to the cost object (Da Silva Medeiros et al., 2017). TDABC provides both accurate and estimates of care cycle costs, as well as greater transparency into the drivers of those costs (Kaplan & Haas, 2018).

TDABC able to calculate true cost of care for individual patients and identified process whose efficiency can be improved without affecting the outcome (Beriwal & Chino, 2018). TDABC is able to deal with variability of industrial process (Barros & Da Costa Ferreira, 2017). TDABC helped efficiently cost processes and overcome challenge associated with current cost-accounting methods (Keel et al., 2017).

TDABC provided detailed baseline calculations for comparison and further optimization of cost-benefit effectiveness (Andreasen et al., 2017). Goense et al. (2017) revealed cost reduction and quality improvements and van der Linden et al. (2017) discovered technique cost effectiveness.

Moreover, TDABC provided valuable insights into process variability and resource utilization (Anzai et al., 2017). According to Zhuang & Chang (2017) TDABC attributed unused resources and provided significant information on idle capacities. The TDABC costs provide an accurate and transparent picture of all the expenses associated with surgical procedures and recovery (Kaplan & Haas, 2018).

On the other hand, TDABC had limitation as well, namely that the use of time equations presupposes that it is possible to estimate time requirements for a particular product based on a limited number of product characteristics. This was not possible in the case study. This may be a “logical” insight, but it is not explicitly addressed in most TDABC literature. Time equations are a very powerful way to describe product variety in a product costing system, but this is not always applicable (Wouters & Stecher, 2017).

2.11 Application of TDABC in different sectors

Since TDABC is introduced, this method has been used in different sectors such as health care, manufacturing, library, logistics and others. Figure 2.10 shows the percentage of TDABC used in different sectors. . The data are collected based on open accessed published papers from 2011-2018 as shown in Appendix A. Based on the pie chart, health care dominated the highest percentage which is 74% while the lowest percentage is 4%, shared by logistics and others. Manufacturing sector is the second highest at 12% and followed by library at 6%. Thus, information of TDABC in manufacturing sector especially in production environment is limited (Mortaji et al., 2013).

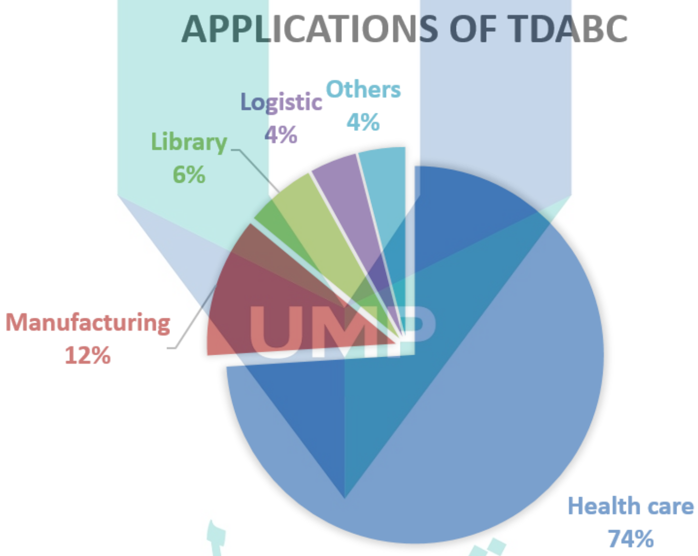

Figure 2.10 Applications of TDABC

2.12 Research gap of TDABC

In this study, TDABC journals are considered and analysed. Those journals are published from 2011-2018 from different journal publications and only open accessed papers are considered. Appendix B shows summary of TDABC journals. Based on Bagherpour et al. (2013) the strengths of TDABC are listed as overcome limitations by ABC, provides accurate costing process, promotes direct allocation, and represents accurate unused capacity. Figure 2.11 displays the proportions of TDABC strength in percentage. This work focussed on accurate costing process to develop the research gap. This is because it is the strength that practices the most elements of TDABC. The elements of TDABC are process mapping, time equation, capacity cost rate, unused capacity and forecasting. There are seven journals that discussed about accurate costing process. From there, this work can identify the elements used by the other studies.

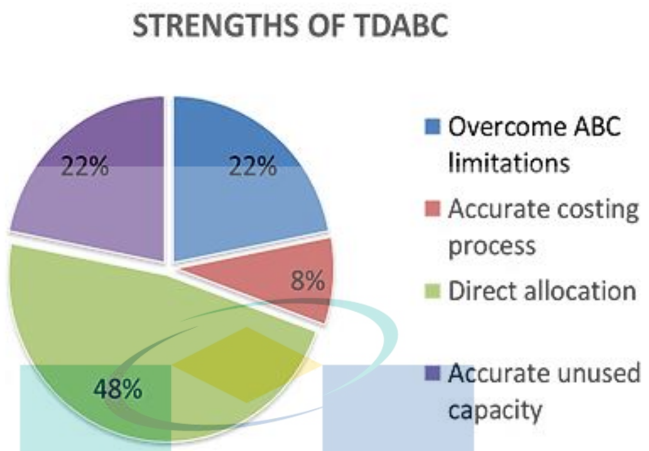

Figure 2.11 Strengths of TDABC discussed in journals

First of all, as stated in Table 2.2, referring to Akhavan et al. (2016) and Helmers et al. (2017) unused capacity was not defined in order to have accurate costing information while forecasting is crucial for any decision making process. In Zhuang & Chang (2017) and Somapa et al. (2012) work, both did not emphasize process mapping that is important to understand the process, the activities and sub-activities. The work from Wouters & Stecher (2017) and Afonso & Santana (2016) did not emphasize on process mapping which the element could give a clear view on the actual activity. According to Bagherpour et al. (2013) forecasting was not mention and it is better to have supported information for the future analysis. Process mapping was not highlighted as well to have detail insight on the activities for costing.

Table 2.2 Elements of TDABC

Author	Process mapping	Time equation	Capacity cost rate	Unused capacity	Forecasting
(Akhavan, Ward, & Bozic, 2016)	✓	✓	✓	×	×
(Helmers et al., 2017)	✓	✓	✓	×	×
(Zhuang & Chang, 2017)	×	✓	✓	✓	×
(Bagherpour et al., 2013)	×	✓	✓	✓	×
(Somapa et al., 2012)	×	✓	✓	✓	✓
(Wouters & Stecher, 2017)	×	✓	✓	✓	✓
(Afonso & Santana, 2016)	×	✓	✓	✓	✓

Therefore, this work intends to fill the gap on TDABC elements which had not been discussed by the seven authors by portraying the costing method at the company. This work focuses on all five elements which are process mapping, time equation, capacity cost rate, unused capacity and forecasting. Process mapping requires detail understanding on the process flow so that the time equations can be placed objectively according to activities. By using information from capacity cost rate, time equation and unused capacity, the forecasting element of TDABC can be used to contribute more information to the company.

2.13 Summary

This chapter discuss on the literature review of both method in this work which are ABC and TDABC. The definitions and implementation concepts from various sectors are reviewed. This chapter highlights the advantages and disadvantages of ABC and TDABC and the method application in the industry. This chapter ends with the discussion of research gap of ABC and TDABC. From the literature, it can be concluded that there is a need to fill the gap by focussing on the elements of ABC and TDABC. This can be done by implementing ABC and TDABC at the company. A comparative study of both methods can provide insights to the company on which costing method suitable for the company and any other similar industry.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, the steps to apply Activity-based Costing (ABC) and Time-driven Activity-based Costing (TDABC) method are discussed. The purpose of this methodology is to ensure that all process of this research follows from the beginning until the end of this project. The steps carried out in this study are summarized in the flowchart.

Throughout this research, product cost, time equation and capacity cost rate is studied. The product used in this study is an inductor. The data collected from an electrical and electronic production company in Kuantan, Pahang. It is an innovative global electronics company supplying the automotive, medical devices, industrial and defence components applications.

3.2 Flow chart

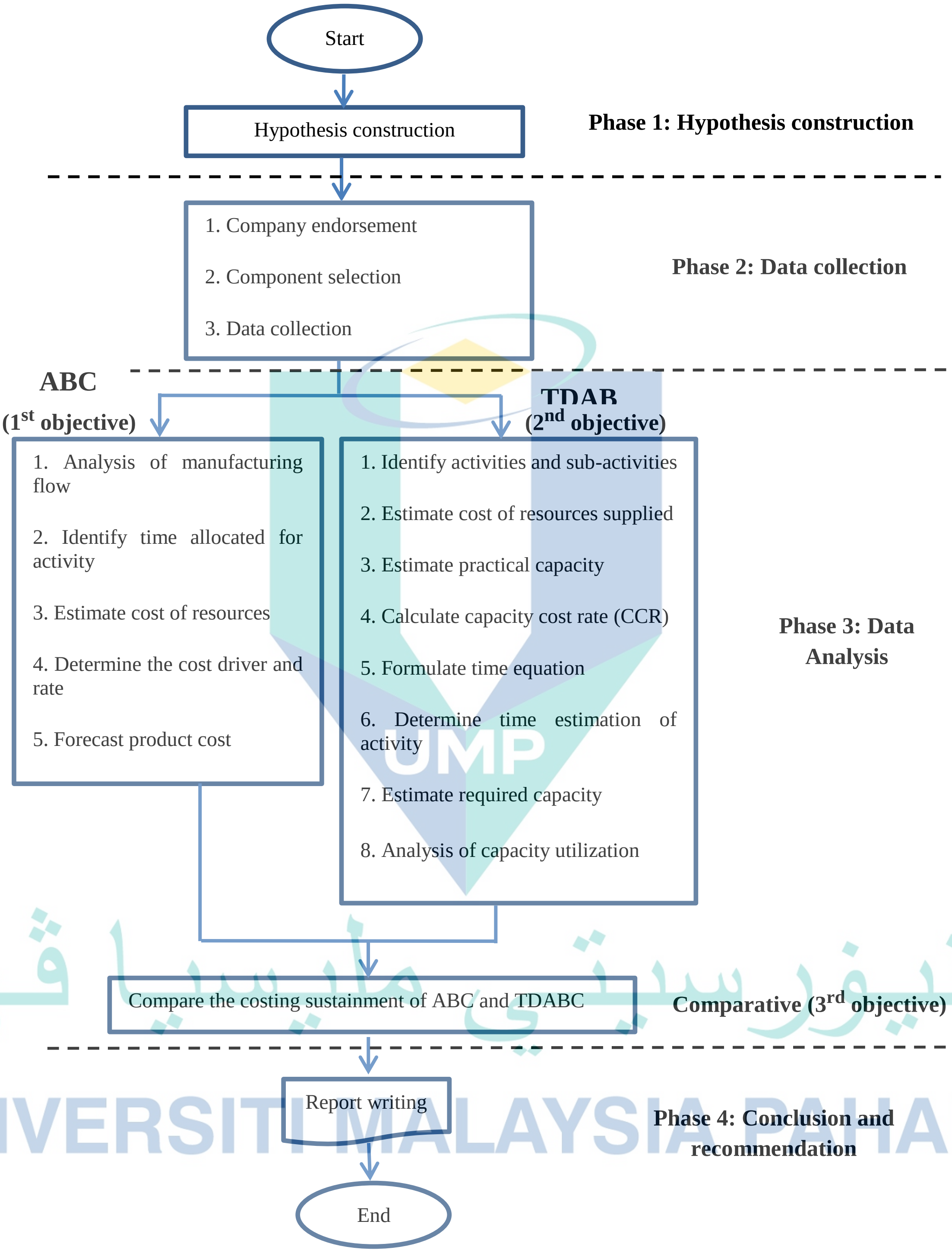

Figure 3.1 Research flow chart

3.3 Phase 1: Hypothesis construction

1. ABC reflects the time allocation and cost drivers and cost driver rates of the activities.

2. TDABC methodology has impact on capacity cost rate, forecasting and capacity utilization of the product.

3. ABC and TDABC method affect the costing sustainment based on features which is multiple cost drivers and forecast.

3.4 Phase 2: Data collection

3.4.1 Company background

The endorsement company is a company that manufacture magnetics components. These magnetics components are made for automotive, medical devices, industrial and defence components applications. The company established in May 1975, has been an innovator and leader in electronic components.

3.4.2 Selection of electronic component

The company are experienced in manufacturing magnetics products with current range of transformers, inductors and chokes. The component chosen as a subject of this study is a magnetic inductor. There are several types of magnetic inductors, consequently HA00-XXX is selected for this study. It is because of it has stable production and the production is continuous throughout the year. Furthermore, this product is chosen because it represents various types of process in the production line.

3.4.3 Data collection

This research has identified the process of making inductor which consists of 13 steps. The process begins at workstation 1 which is winding process using Computer Numerical Control (CNC) machine. Next, the coils are flattened at workstation 2. Then at workstation 3, the coils undergo trimming process. At workstation 4, the process is to bend the ends of the coil into 90°. The next process is where the ends of the coil are soldered at workstation 5. At workstation 6, epoxy resin is applied onto a material called core. Meanwhile at workstation 7, the coil from workstation 5 which is the soldering process is assembled with a material called bottom core. Then, the core and bottom core from workstation 6 and workstation 7 respectively are assembled together for assembly 2 at workstation 8. Thus, the full assembly process of an inductor is now completed. The clipped inductors are left in curing oven at workstation 9. After that, the inductors undergo boundary inspection at workstation 10. Then, the inductors are laser-marked at workstation 11. At workstation 12, the inductors undergo co-planarity inspection and Visual and Mechanical Inspection (VMI) for further inspection. Finally, the inductors are packed at workstation 13.

3.4.3.1 Semi-structured questions

This study conducts a survey by interviewing operators, engineers and management staff to obtain information of the activities. Table 3.1 shows example of semi-structured questions.

Table 3.1 Example of semi-structred questions interview table

Activity	Question	Respondent	Answers
Winding	What is the average cycle time for this activity to be completed?	Respondent 1	
		Respondent 3	
		Respondent 3	
		Respondent 4	
		Respondent 5	

3.4.3.2 Time study

This work conduct a time study for all of activities. The cycle time for an activity is recorded using a stopwatch for five times. The total of accumulative time taken is divided with number of cycles taken. The sample of time study table shown in Table 3.2.

Table 3.2 Example of time study table

Activity	Cycle					Total	Average
	1	2	3	4	5		
Winding	0.56	0.55	0.54	0.56	0.55	2.76	0.55

3.4.3.3 Cost capacity estimation

The cost of capacity are estimated in terms of four categories which are labor, maintenance, material and consumable cost. Labor cost is the amount of salary of the operator while maintenance cost is the cost of part replacement of machineries. Material cost is the cost of raw material used for production of the product. Consumable cost is the cost of material and equipment used but not incorporated in the product. Table 3.3 shows the example of cost allocation for labor, maintenance, material, consumable and resources.

Table 3.3 Example of labor, maintenance, material, consumable and resources cost

Activity	Sub-activities	Labor (MYR)	Maintenance (MYR)	Material (MYR)	Consumable (MYR)	Cost of all resources supplied (MYR)
Flattening	Pick up the coils from winding station	12,000	300.00	13,000	100.00	25,400
	Flatten the coils by using hydraulic press machines	36,000	70.00	-	144.00	36,214

3.5 Phase 3: Data analysis

There are two phases of data analysis which are by using ABC method and TDABC method. This study proceeds with ABC method which consists of five steps and then proceeds with TDABC method which consists of eight steps.

3.5.1 Activity-based Costing (ABC)

In this study, there are five steps of implementing ABC system. Firstly, manufacturing flow analysis. The first step of implementing ABC is to do a manufacturing flow analysis on the production line. In this step, all activities in the production line are described.

Secondly, a survey for time allocation in activities is identified. The sample size for this survey is 33. For every workstation, the time allocated by operator to complete the task given is identified. The time allocation is collected as an average, by interviewing the operators and by observation.

Thirdly, the calculation of cost of capacity is conducted. Cost of capacity is to calculate the cost of all the resources such as labor, equipment, and technology supplied to the department or process. In this study, the cost of capacity resources of each activity is calculated in terms of (i) labor costs, (ii) maintenance costs, (iii) material costs, and (iv) consumable costs. Labor cost is the amount of salary of the operator while maintenance cost is the cost of part replacement of machineries. Material cost is the cost of raw material used for production of the product. Consumable cost is the cost of material and equipment used but not incorporated in the product.

Next, the cost drivers and rate of activities are determined. Cost driver is determined by taking the factors that influence the cost in an activity. Cost driver rates are calculated by dividing the cost of resources and the cost quantity driver for each activity.

Lastly, the step is concluded with forecasting product cost. Using cost driver rate, product cost is forecast. Thus, this work complied with first objective which is to identify the cost drivers of ABC for costing development.

3.5.2 Time-driven Activity-based Costing (TDABC)

TDABC system consists of eight steps of implementation. Firstly, the identification of activities and sub-activities are conducted. This step is to identify activities and sub-activities at workstations at the production line.

Second step is to estimate cost of resources supplied. In this study, the resources allocated are based on 4 groups: (i) labor costs, (ii) maintenance cost for the machinery (iii) raw materials costs and (iv) consumable material costs.

The third step is to do an estimation of practical capacity: The practical capacity of labor is estimated by summating number of working hours annually.

Next step is to calculate capacity cost rate. The capacity cost rate (MYR per minute) can be obtained using the following Equation 3.1.

$$\text{Capacity cost rate} = \frac{\text{Cost of all resources supplied}}{\text{Practical capacity}} \quad 3.1$$

Furthermore, the time equation is formulate by using TDABC time equation as shown in Equation 3.2.

$$Tt = \beta_0 + \beta_i \chi_i \quad 3.2$$

Where;

Tt = the time needed to perform an activity (minute)

β_0 = the standard time to perform the basic activity (minute)

β_i = the estimated time to perform the incremental activity (minute)

χ_i = the quantity of the incremental activity (time)

Estimation of time for sub-activity is the continuity of TDABC steps. The estimated time for each activity is obtained by observation of the operators completing tasks.

The TDABC steps are continued with estimation of required capacity for sub-activity. The estimated capacity required by each activity was determined by quantifying the frequency of the activity in a month.

The last step for implementing TDABC method is to analyse the capacity utilization. Unused capacity can be obtained by using Equation 3.3 and unused cost can be obtained by using Equation 3.4.Thus, the implementation of TDABC complied with the second objective which is to appraise the role of capacity cost rate and time equation.

$$\text{Unused capacity} = \text{Practical capacity} - \text{used time} \quad 3.3$$

$$\text{Unused cost} = \text{Capacity cost rate} \times \text{unused time} \quad 3.4$$

3.5.3 Comparative study

A comparative study is carry out to prove the differences of ABC and TDABC based on eight features of costing sustainment. There are number of stages for cost allocation in ABC and TDABC, determination of drivers, action taken for an additional activity, cost consideration for implementation, information given from each method, transparency, oversimplification of activities and capacity forecast and planning.

Cost allocation is a process of classifying, collecting and assigning cost to cost objects. Cost driver is the activity that contributes the most of cost in an activity. Additional activity is any new activity added to the production line. Moreover, cost consideration feature focuses on cost consideration of steps in implementing ABC and TDABC. A system is considered informative when it is able to deliver useful or interesting information. Transparency is an ability to show in detail the duration of an activity. Number of driver is a center of discussion for oversimplification of activities feature. Forecast and planning step is crucial as it predicts the future action and scenario.

Both ABC and TDABC method would be analysed by using the costing sustainment features. Every feature would be discussed accordingly by using data obtain from the company. For every feature, there would be a comparison of how implementation of ABC and TDABC differs and to what extend does a method would be able to give information to the company. Eventually, the company would be able to compare of both ABC and TDABC implementation method. Therefore, the comparative study complied with the third objective which is to compare ABC and TDABC costing sustainment by using the features.

3.6 Phase 4: Conclusion and recommendation

This phase concludes findings of this work on every step of implementation of ABC and TDABC. The comparative study of ABC and TDABC is concluded as well. The research questions and objective would be coordinated with the findings of this work. The future recommendation for further study would be stated in this phase.

3.7 Summary

This chapter conveys the methodology of implementing process of ABC and TDABC for this research. Description of the detailed processes and methods of analysing data using ABC and TDABC system were discussed. The comparative features of this study are described as well. Thus, the methodology of this work covers first, second and third objectives.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter discuss in detail of implementation of Activity-based Costing (ABC), Time-driven Activity-based Costing (TDABC), and comparative study of ABC and TDABC.

4.2 Manufacturing flow analysis

The first step of implementing ABC is to do a manufacturing flow analysis on the production line. In this step, all activities in the production line are described. There are 13 workstations to produce a magnetic inductor as starting from CNC winding until packaging. The production flow is illustrated as in Figure 4.1. Each workstation activities are described in detail in a paragraph.

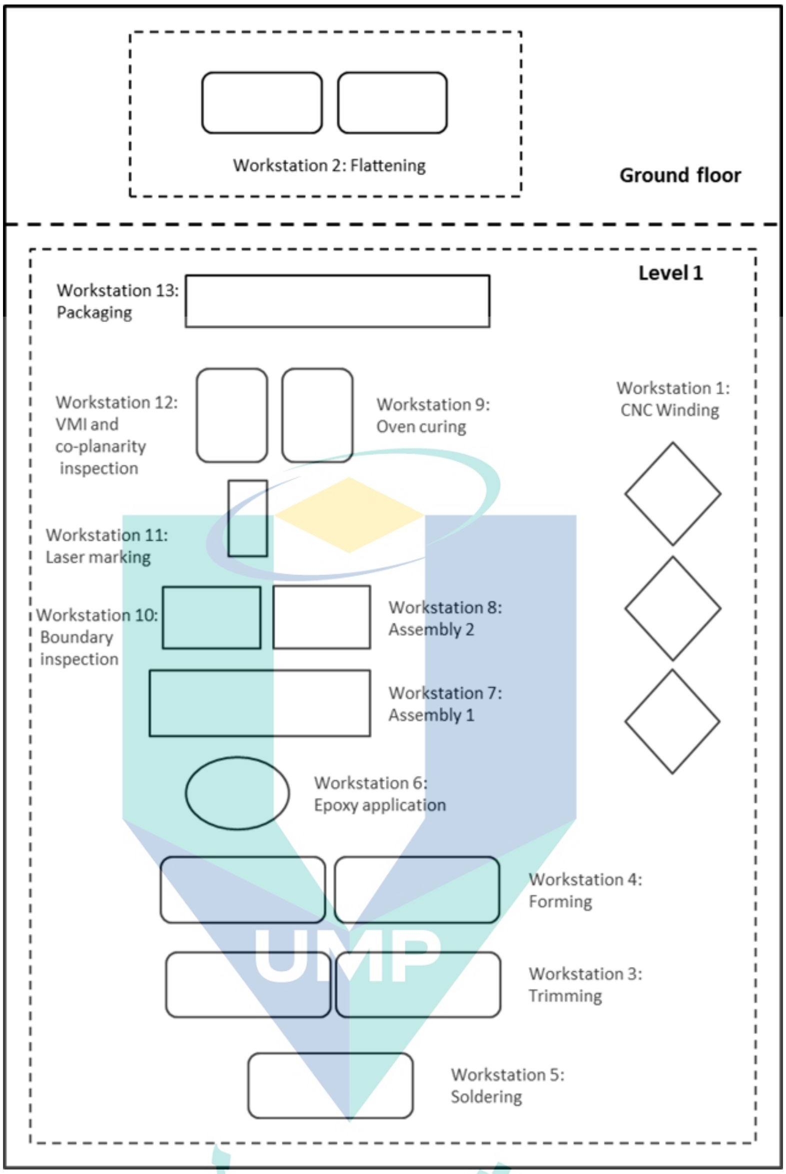

Figure 4.1 Production flow

The process starts with workstation 1 and ends with workstation 13. Note that only workstation 2 is on ground floor where as the others are on level 1.

The process of making the inductor begins at workstation 1 which is winding process using Computer Numerical Control (CNC) machine. There are three CNC machines for this workstation. A rectangular wire is being winded into coil. An auto feeder machine pulls the wire from spool into the CNC machine. At specified area, the wire will be stripped.

Next, both ends of the coil are flattened at workstation 2. There are two hydraulic press machines in this workstation. Firstly, the operators needed to collect coils from workstation 1. The process started by putting 5 pieces of coil onto flattening fixture and pushing the fixture into the machine. Then, switch button is pushed to execute the flattening process. After the coils are flatten, the fixture is pulled out and the coils are removed. A brush is used to remove any chips from the fixture.

Then at workstation 3, the coils undergo trimming process. The process is done by using two pneumatic press machines. It is to trim excess ends of the coils. 2 pieces of coil are put into a trimming fixture and the operators pushed switch buttons to execute the process. A brush is used to clean the jig from unwanted chips after the coils are removed.

At workstation 4, the process is to bend the ends of the coil into 90°. There are two pneumatic press machines used. The operators put 3 pieces of coil into jigs and press the buttons to bend the coils. The jigs are designed to let the coils fall into a container after the bending process. A brush is used to eliminate unwanted chips.

The next process is where the ends of the coil are soldered at workstation 5. The coils are picked up and inserted into a pair tong. The coils are first dipped into flux solution before being soldered. Soldered coils are put into a container and ready to be transferred to next workstation.

At workstation 6, epoxy resin is applied onto a material called core. There are 2 steps of application which are 3-dots and 4-dots on the same core piece. The cores are arranged on magnetic strips before being transferred into machine slots. The strips are manually transferred by operator in between 3-dots and 4-dots application.

Meanwhile at workstation 7, the coil from workstation 5 which is the soldering process is assembled with a material called bottom core. The operators need to check for any defects on the coils before proceed with the assembly process.Then, the core and bottom core from workstation 6 and workstation 7 respectively are assembled together for assembly 2 at workstation 8. Thus, the full assembly process of an inductor is now completed.

Each inductor needs to be clipped for the adhesive to be secured before going for next workstation which is curing process. The clipped inductors are left in curing oven for 30 minutes and cool down over fan for 10 minutes. This is done at workstation 9.

After that, the clips are removed, and the inductors undergo boundary inspection at workstation 10. The operators slide the inductors using specialized jig made for this workstation to inspect the product dimension.

Then, workstation 11 is a laser-marking process on top surface of each inductor. Each inductor undergoes laser marking for 1.8 seconds. This process provides information details of the product to the consumer.

At workstation 12, the inductors undergo co-planarity inspection and Visual and Mechanical Inspection (VMI) for further inspection in case there are any defects.

Finally, at the last workstation which is packaging, bubble wraps are used to wrap the reels to minimize impact during movements. Then, wrapped reels are packed into boxes and ready to send to customers.

4.3 Time allocation

For every workstation, the time allocated by operator to complete the task given is identified. The time allocation is collected as an average, by interviewing the operators and by observation. The sample size for this survey is 33 operators. The time allocation from interviews and observation are revealed in Table 4.1 for all activities.

Table 4.1 Time allocation for all activities

Activity	Time allocation (%)
Winding	16.51
Flattening	1.27
Trimming	1.27
Forming	1.27
Soldering	12.70
Epoxy application	43.89
Assembly 1	14.55
Assembly 2	1.27
Oven curing	0.63
Boundary inspection	0.64
Laser marking	0.65
Co-planarity inspection and VMI	4.08
Packaging	1.27
Total	100

The largest time allocation by operators is at epoxy application workstation which is 43.89%, followed by winding workstation at 16.51%, and assembly 1 workstation at 14.55%. At epoxy application, the time is consumed largely with the application of 3-dots and 4-dots of epoxy on every single core. The number of epoxy applicator plays an important role against the time taken. In order to shorten the time taken, the number of applicators can be increase and can be applied simultaneously at one time. As for winding workstation, the time allocated is largely influenced by the speed and the machine mechanism. While for assembly 1, the time allocated is largely influenced by operators.

4.4 Cost of capacity estimation

Cost of capacity is to calculate the cost of all the resources such as personnel, supervision, equipment and technology supplied to the department or process. In this study, the cost of capacity resources of each activity is calculated in terms of (i) labor costs, (ii) maintenance costs, (iii) material costs, and (iv) consumable costs. Details of costs incurred in each activity are in Table 4.2. Table 4.2 shows the annual expenses for the magnetic inductor production for each activity. Labor cost is the amount of salary of the operator while maintenance cost is the cost of part replacement of machineries. Material cost is the cost of raw material used for production of the product. Consumable cost is the cost of material and equipment used but not incorporated in the product.

Table 4.2 Labor, maintenance, material, consumable and all resources cost

Workstation	**Labor (MYR)**	**Maintenance (MYR)**	**Material (MYR)**	**Consumable (MYR)**	**Cost of all resources supplied (MYR)**
Winding	24,000.00	26,449.89	576,000.00	nil	626,449.89
Flattening	48,000.00	70.00	nil	144.00	48,214.00
Trimming	48,000.00	nil	nil	192.00	48,192.00
Forming	48,000.00	nil	nil	192.00	48,192.00
Soldering	24,000.00	nil	432,000.00	26,024.32	482,024.32
Epoxy application	24,000.00	nil	1,641,600.00	129.98	1,665,729.98
Assembly 1	72,000.00	nil	480,000.00	403.20	552,403.20
Assembly 2	48,000.00	nil	nil	268.80	48,268.80
Oven curing	24,000.00	nil	nil	24.00	24,024.00
Boundary inspection	24,000.00	nil	nil	134.40	24,134.40
Laser marking	24,000.00	626.53	nil	nil	24,626.53
Co-planarity and VMI	24,000.00	nil	nil	130,824.00	154,824.00
Packaging	24,000.00	nil	nil	24,384.00	48,384.00
Total	MYR 456,000.00	MYR 27,146.42	MYR 3,129,600.00	MYR 182,720.70	
Grand total			MYR 3,795,467.12		

There are two shifts daily for every activity. Table 4.2 shows total annual labor cost for the production line. For this specific production line of a magnetic inductor, the total number of operators is 38 daily. The annual salary of one operator is MYR 12,000. The operators work for 8 hours and 35 minutes for 5 days a week.

Based on Table 4.2, the costs of maintenance are listed. The winding activity has several maintenances to replace machine parts. The winding activity has replaced micro grinders, adjustable forming slider, tight cylinders, diamond mounted points, spindle, handler, bearing and stripper motor. The total maintenance cost for winding activity is MYR 26,449.89. The flattening workstation has one maintenance which is to replace flexible hose which costs MYR 70. For laser marking activity, the maintenance cost is MYR 626.53 which is to replace stepper motor and vacuum filter. This work finds that there is no allocated amount of maintenance for other activities.

As stated in Table 4.2, the cost of material for winding activity is MYR 576,000. The material used is a rectangular copper wire with dimension of 0.80 mm x 2.3 mm. The material used at soldering activity costs MYR 432,000 which is for solder bar. MYR 1,641,600 is spent for epoxy resin and core. Bottom core is used as material for assembly 1 activity with the cost of MYR 480,000. This work finds that there is no allocated amount of material for other activities as the activities used materials from the continuation of previous activity.

The consumable cost of MYR 144 is spent for finger coats at flattening activity. The consumable cost of MYR 192 is spent at trimming and forming activity for finger coats and brushes. Soldering activity uses rosin flux solution, masks, and rubber gloves which cost MYR 26,024.32. For epoxy activity, masks, finger coats, and tissues are categorized as consumables with the cost of MYR 129.98. The cost of consumable for assembly 1 and assembly 2 is MYR 403.20 and MYR 268.80 respectively which are spent for finger coats and masks. Gloves are used by the operators and categorized under consumable cost with amount of MYR 24.00. There is amount of MYR 134.40 of consumable that comprises of finger coats and face masks for boundary inspection activity. For co-planarity and VMI activity, the cost of MYR 130,824.00 is spent for reels, carrier tapes and brushes. For packaging activity, MYR 24,384.00 is due to two types of boxes used, bubble wraps and tapes.

The total expenses of labor, maintenance, material and consumable are at MYR 456,000.00, MYR 27,146.42, MYR 3,129,600.00 and MYR 182,720.70 respectively. The highest amount of cost allocated is for material, followed by consumable cost. The grand total for magnetic inductor annual production is MYR 3,795,467.12.

4.5 Cost driver and rate determination

The cost driver is determined by making assumption that the time allocated by each operator at each workstation takes about the same level of effort. It is chosen based on the consideration of the cost that influence the most in the workstation. Next, the ABC system calculated the following cost driver rates as shown in Table 4.3.

Table 4.3 shows the cost driver rates for the magnetic inductor production using ABC. The cost driver quantity is the estimated quantities of products produced for a year in all 13 activities. Cost driver rates are calculated by dividing the assigned cost and the cost quantity driver for each activity.

Table 4.3 Cost driver rates for all activities

Activity	Cost driver	Cost of all resources supplied (MYR)	Cost driver quantity	Cost driver rate (MYR)
1. Winding	Amount of raw material (g)	626,449.89	8,697,600	0.07
2. Flattening	Hydraulic press machine (frequency)	48,214.00	960,000	0.05
3. Trimming	Pneumatic machines (frequency)	48,192.00	2,400,000	0.02
4. Forming	Pneumatic machines (frequency)	48,192.00	2,400,000	0.02
5. Soldering	Amount of material used (g)	482,024.32	2,400,000	0.20
6. Epoxy application	Amount of material used (g)	1,665,729.98	4,800,000	0.35
7. Assembly 1	Amount of material (quantity)	552,403.20	4,800,000	0.12
8. Assembly 2	Amount of material (quantity)	48,268.80	4,800,000	0.01
9. Oven curing	Clipping process (frequency)	24,024.00	4,800,000	0.01
10. Boundary inspection	Product items (quantity)	24,134.40	4,800,000	0.01
11. Laser marking	Laser marking machine (frequency)	24,626.53	4,800,000	0.01
12. Co-planarity and VMI	Inspection (frequency)	154,824.00	4,800,000	0.03
13. Packaging	Product items (quantity)	48,384.00	4,800,000	0.01
Total		3,795,467.12		

The cost driver of forming activity is frequency of pneumatic machine being used. The cost driver rate of forming activity is MYR 0.02. By using cost driver rate in Table 4.3, the unit product cost can be forecast according to demand quantity.

4.6 Forecast product cost

Using the product cost information in 2018, the product cost can be forecasted. For example, in the following year, the demand of the magnetic inductor increases as much as 10%; while maintaining the production line process, number of labor and equipment, how much is the predicted product cost?

Table 4.4 shows the forecast of product cost respect to the demand quantity using cost rate. The production line is expected to produce 5,280,000 quantities of magnetic inductor. As the demand quantity of the product is increase by 10%, the total cost of production is predicted to be MYR 4,260,115.20 while the unit product cost is forecast at MYR 0.81.

Table 4.4 Magnetic inductor forecast cost

Activity	Activity cost driver	Cost driver rate (MYR)	Cost driver quantity	Forecast cost (MYR)
1. Winding	Amount of raw material (g)	0.07	9,567,360	669,715.20
2. Flattening	Hydraulic press machine (frequency)	0.05	1,056,000	52,800.00
3. Trimming	Pneumatic machines (frequency)	0.02	2,640,000	52,800.00
4. Forming	Pneumatic machines (frequency)	0.02	2,640,000	52,800.00
5. Soldering	Amount of material used (g)	0.20	2,640,000	528,000.00
6. Epoxy application	Amount of material used (g)	0.35	5,280,000	1,848,000.00
7. Assembly 1	Amount of material (quantity)	0.12	5,280,000	633,600.00
8. Assembly 2	Amount of material (quantity)	0.01	5,280,000	52,800.00
9. Oven curing	Clipping process (frequency)	0.01	5,280,000	52,800.00
10. Boundary inspection	Product items (quantity)	0.01	5,280,000	52,800.00
11. Laser marking	Laser marking machine (frequency)	0.01	5,280,000	52,800.00
12.Co-planarity and VMI	Co-planarity inspection (frequency)	0.03	5,280,000	158,400.00
13. Packaging	Product items (quantity)	0.01	5,280,000	52,800.00
	Total (RM)			4,260,115.20
	Unit (RM)			0.81

The forecast of total cost production of magnetic inductor is the summation of forecast cost from all 13 activities. The forecast unit product cost is obtained by dividing the total of MYR 4,260,115.20 with the expected demand which is 5,280,000. Thus, a single unit of a magnetic inductor is forecasted to cost as much as MYR 0.81.

4.7 Strength of Activity-Based Costing (ABC)

Throughout the process, the current company cost information is analysed and compared with cost information by ABC method. It is discovered that the company applied their costing on activity based rather than volume based. Lead time for each workstation is used to generate the product cost.

Table 4.5 shows the cycle time for a product process to be completed. The cycle time for each activity is collected. The total time for all activities is 0.7250 hours. There is a 20% allowance of cost added to the total cost for allocation of maintenance, operators' short break and unproductive time. The 20% of allowance is obtained from historical data. Thus, the grand total time for this process to be completed is 0.87 hours.

Table 4.5 Product cycle time

Step	Process	Cycle Time (Hours)
1.	Winding	0.1312
2.	Label leadouts	0.0056
3.	Cut lead & bend wires	0.0056
4.	Oven curing	0.0006
5.	Solder coat pins	0.0052
6.	Pre-solder leadouts	0.1597
7.	Hook up leadouts to pin	0.0944
8.	Pin soldering	0.0278
9.	Inspection	0.0662
10.	Test	0.002
11.	Assembly	0.0587
12.	Inductance test	0.0185
13.	TSE application	0.0066
14.	Oven curing	0.0006
15.	Final test	0.0667
16.	Full final inspection	0.0750
17.	Packaging	0.0005
	Total	0.7250
	20% Allowance	0.1450
	Grand total	0.87

An example of the company's costing structure for a product is as shown in Table 4.6. Material handling unit (MHU) is the accumulation of cycle time of all activities from Table 4.5 which is 0.87 hours. Bill of material (BOM) is the accumulation of cost of material used in every activity for the process. The total BOM cost for this product is US$ 1.6895. Labor and overhead (LOH) is the multiplication of MHU and LOH rate which is US$ 4.0. From Table 4.6, 3.48 of LOH is the result of multiplication of 0.87 MHU with US$ 4.0. Finally, the total cost is the summation of LOH and BOM, US$ 5.1695. Therefore, the cost of a product is generated.

Table 4.6 The product total cost

Product No.	MHU	BOM	LOH US$ 4.0	Total cost US $
XXX	0.87	1.6895	3.48	5.1695

Nevertheless, this section reveals the strength of ABC throughout the implementation phase at the production line. ABC provides information on the cost drivers as shown in Table 4.3. All cost drivers of the 13 activities are identified. The company may have implemented the costing using activity based however, the cost drivers are not significantly pointed out. Meanwhile, ABC method is able to point out cost drivers in every workstation. Therefore, this work complied with first objective which is to identify the cost drivers of ABC for costing development.

4.8 TDABC implementation: Cost of resources estimation

The first step of implementing TDABC is to identify activities and sub-activities. This work found that there are 13 activities which are further narrowed down to 17 sub-activities in the production line to produce a magnetic inductor. The activities and sub-activities are stated in Table 4.7.

The second step is to estimate the total cost of resources supplied. The resources allocated are based on 4 groups: (i) labor costs, (ii) maintenance cost for the machinery (iii) raw materials costs and (iv) consumable costs. The costs incurred are detailed in the Table 4.7. Labor cost is the amount of salary of the operator while maintenance cost is the cost of part replacement of machineries. Material cost is the cost of raw material used for production of the product. Consumable cost is the cost of material and equipment used but not incorporated in the product.

Table 4.7 Labor, maintenance, material and consumable cost for 17 sub-activities

Activity	Sub-activities	Labor (MYR)	Maintenance (MYR)	Material (MYR)	Consumable (MYR)	Cost of all resources supplied (MYR)
1. Winding	1. The wire are winded using CNC machine	24,000	26,449.89	576,000	nil	626,449.89
2. Flattening	2. Pick up the coils from winding station	12,000	nil	nil	nil	12,000
	3. Flatten the coils by using hydraulic press machines	36,000	70.00	nil	144.00	36,214
3. Trimming	4. Pick up the coils from flattening station	12,000	nil	nil	nil	12,000
	5. Trim the coils by using pneumatic press machines	36,000	nil	nil	192.00	36,192
4. Forming	6. Bend the coils by using pneumatic press machines	48,000	nil	nil	192.00	48,192
5. Soldering	7. Dip the coils into flux	12,000	nil	nil	12,960	24,960
	8. Then, dip the coils into solder	12,000	nil	432,000	13,064.32	457,064.32
6. Epoxy application	9. Arrange core on the magnetic strip	12,000	nil	1,440,000	nil	1,452,000
	10. Put the magnetic strip into the epoxy machine.	12,000	nil	201,600	129.98	213,729.98
7. Assembly 1	11. Assemble coil to the I-core.	72,000	nil	480,000	403.2	552,403.2
8. Assembly 2	12. Assemble core with I-core.	48,000	nil	nil	268.80	48,268.8
9. Oven Curing	13. Put the inductor into oven	24,000	nil	nil	24.00	24,024
10. Boundary inspection	14. The inductors undergo boundary inspection	24,000	nil	nil	134.4	24,134.4
11. Laser marking	15. Put the inductors into laser marking machine	24,000	626.53	nil	nil	24,626.53
12. Co-planarity and VMI	16. Inspect inductors for co-planarity and then into VMI equipment.	24,000	nil	nil	130,824	154,824.00
13. Packaging	17. Pack inductors	24,000	nil	nil	24,384.00	48,384.00
Total		456,000	27,146.42	3,129,600	182,720.70	3,795,467.12

4.9 Practical capacity estimation

The factory's working hours are from Monday to Friday, 8 a.m. to 5.35 p.m. The operators work for 8 hours and 35 minutes per day, excluding 1 hour break daily, for 20 days a month. Each operator has an acceptable capacity of 10,300 minutes every month. Therefore, the practical capacity per year is 123,600 minutes for every operator. The practical capacity of every activity is shown in Table 4.8.

4.10 Capacity cost rate calculation

Capacity cost rate for each activity and sub-activity is as portrayed in the Table 4.8. Capacity cost rate is calculated using the formula in Equation 3.1.

Table 4.8 Capacity cost rate of each sub-activity

Activity	Sub-activities	Cost of all resources supplied (MYR) [1]	Practical capacity (min) [2]	Capacity cost rate (MYR) [1]/[2]=[3]
1. Winding	1. The wire are winded using CNC machine	626,449.89	247,200	2.53
2. Flattening	2. Pick up the coils from winding station	12,000	123,600	0.10
	3. Flatten the coils by using hydraulic press machines	36,214	370,800	0.10
3. Trimming	4. Pick up the coils from flattening station	12,000	123,600	0.10
	5. Trim the coils by using pneumatic press machines	36,192	370,800	0.10
4. Forming	6. Bend the coils by using pneumatic press machines	48,192	494,400	0.10
5. Soldering	7. Dip the coils into flux	24,960	123,600	0.20
	8. Then, dip the coils into solder	457,064.32	123,600	3.70
6. Epoxy application	9. Arrange core on the magnetic strip	1,452,000	123,600	11.75
	10. Put the magnetic strip into the epoxy machine.	213,729.98	123,600	1.73
7. Assembly 1	11. Assemble coil to the I-core.	552,403.20	741,600	0.74
8. Assembly 2	12. Assemble core with I-core.	48,268.80	494,400	0.10
9. Oven curing	13. Put the inductor into oven	24,024	247,200	0.10
10. Boundary inspection	14. The inductors undergo boundary inspection	24,134.40	247,200	0.10
11. Laser marking	15. Put the inductors into laser marking machine	24,626.53	247,200	0.10
12. Co-planarity and VMI	16. Inspect inductors for co-planarity and then into VMI equipment.	154,824.00	247,200	0.63
13. Packaging	17. Pack inductors	48,384.00	247,200	0.20
	Total	Total	4,696,800	

4.11 Time estimation of activity and sub-activity

In order to calculate the estimated production time, it is necessary to develop a time equation. The estimated time for each activity was obtained by observation of the operators completing given tasks. The cycle time for an activity is recorded using a stopwatch for five times. The total of accumulative time taken is divided with number of cycles taken. For instance, the average time taken for the wire to be wind by using CNC machine to become a single coil is 0.12 minutes. This figure is multiplied by the relevant variables or cost drivers to develop the time equation, as shown in Table 4.9. Each variable in the time equation is defined in Table 4.10.

Table 4.9 Time equations for all sub-activities

Activity	Sub-activities	Estimated time
1.Winding	1. The wire are winded using CNC machine	$0.12\,\chi_1$
2.Flattening	2. Pick up the coils from winding station	$10.00\,\chi_2$
	3.. Flatten the coils by using hydraulic press machines	$0.22\,\chi_3$
3.Trimming	4. Pick up the coils from flattening station	$10.00\,\chi_4$
	5. Trim the coils by using pneumatic press machines	$0.13\,\chi_5$
4.Forming	6. Bend the coils by using pneumatic press machines	$0.17\,\chi_6$
5.Soldering	7. Pick the coils using pliers and dip the coils into flux	$0.72\,\chi_7$
	8. Then, dip the coils into solder.	$0.18\,\chi_8$
6.Epoxy application	9. Arrange core on the magnetic strip.	$0.15\,\chi_9$
	10. Put the magnetic strip into the epoxy machine and run the machine.	$2.7\,\chi_{10}$
7.Assembly 1	11. Assemble coil to the I-core	$0.07\,\chi_{11}$
8.Assembly 2	12. Assemble core with I-core.	$0.14\,\chi_{12}$
9.Curing	13. Put the inductor into oven	$0.8\chi_{13}$
10.Boundary inspection	14. The inductors undergo boundary inspection	$0.05\,\chi_{14}$
11.Laser marking	15. Put the inductors into laser marking machine	$0.05\,\chi_{15}$
12.Co-planarity and VMI	16. Inspect inductors for co-planarity and VMI	$0.52\,\chi_{16}$
13.Packaging	17. Pack inductors	$3.00\,\chi_{17}$

4.12 Time equations formulation

From Table 4.9, the time equation for all the sub-activities is formulated.

$$T_{\text{sub-activities}} = 0.12\,\chi_1 + 10.00\,\chi_2 + 0.22\,\chi_3 + 10.00\,\chi_4 + 0.13\,\chi_5 + 0.17\,\chi_6 + 0.72\,\chi_7 + 0.18\,\chi_8 + 0.15\,\chi_9 + 2.7\,\chi_{10} + 0.07\,\chi_{11} + 0.14\,\chi_{12} + 0.8\,\chi_{13} + 0.05\,\chi_{14} + 0.05\,\chi_{15} + 0.52\,\chi_{16} + 3.00\,\chi_{17} \quad (4.1)$$

4.13 Capacity required estimation

The estimated capacity required by each activity was determined by quantifying the frequency of the activity in a month. By multiplying the amount of a given activity by the time allocated doing it, one could calculate the total time allocated on the activity. The volumes of cost drivers for the activity are summarized in Table 4.10.

Table 4.10 Volume of cost drivers for the magnetic inductor

Activity	Var.	Sub-activities	Driver	Quantity/year
1.Winding	χ_1	1. The wire are winded using CNC machine	Amount of raw material (kg)	8,697.6
2.Flattening	χ_2	2. Pick up the coils from winding station	Pick up the coils from winding station (rounds)	480
	χ_3	3. Flatten the coils by using hydraulic press machines	Number of hydraulic press machine operating (frequency)	960,000
3.Trimming	χ_4	4. Pick up the coils from flattening station	Pick up the coils from flattening station (rounds)	480
	χ_5	5. Trim the coils by using pneumatic press machines	Number of pneumatic press machine operating (frequency/month)	2,400,000
4.Forming	χ_6	6. Bend the coils by using pneumatic press machines	Number of pneumatic press machine operating (frequency/month)	2,400,000
5.Soldering	χ_7	7. Pick the coils using pliers and dip the coils into flux	Amount of flux used (litre)	432
	χ_8	8. Then, dip the coils into solder.	Amount of solder used (kg)	2,400
6.Epoxy application	χ_9	9. Arrange core on the magnetic strip.	Arrange core on the magnetic strip (amount of core)	4,800,000
	χ_{10}	10. Put the magnetic strip into the epoxy machine and run the machine.	Amount of epoxy used (litre)	201.6
7.Assembly 1	χ_{11}	11. Assemble coil to the I-core	Amount of material (quantity)	4,800,000
8.Assembly 2	χ_{12}	12. Assemble core with I-core.	Amount of material (quantity)	4,800,000
9.Oven curing	χ_{13}	13. Put the inductor into oven	Clipping process (frequency)	4,800,000
10.Boundary inspection	χ_{14}	14. The inductors undergo boundary inspection	Product item (quantity)	4,800,000
11.Laser marking	χ_{15}	15. Put the inductors into laser marking machine	Laser marking machine (frequency)	4,800,000
12.Co-planarity and VMI	χ_{16}	16. Inspect inductors for co-planarity and VMI	Inspection (frequency)	4,800,000
13.Packaging	χ_{17}	17. Pack inductors	Product items (quantity)	12,000

The actual time allocated on this activity center per month was determined by substituting the volume of cost-drivers from Table 4.10 into Equation 4.1, as shown below.

The actual time allocated = (0.12x8,697.6) + (10x480) + (0.22x960,000) + (10x480) + (0.13x2,400,000) + (0.17x2,400,000) + (0.72x432) + (0.18x2,400) + (0.15x4,800,000) + (2.7x201.6) + (0.07x4,800,000) + (0.14x4,800,000) + (0.8x4,800,000) + (0.05x4,800,000) + (0.05x4,800,000) + (0.52x4,800,000)+ (3x12,000) = 9,523,131.07 minutes

4.14 Analysis of capacity utilization

The last step for implementing TDABC method is to analyse the capacity utilization. Based on the same calculation, the total production cost for each workstation is shown in Table 4.11.

Table 4.11 Analysis of capacity utilization

Activity	Sub-activities	Practical capacity	Used time (min)	Total cost (MYR)	Unused time (min)	Unused cost (MYR)
1.Winding	1.Wind wires using CNC machine	247,200	1,043.71	2,640.59	246,156.29	622,775.41
2.Flattening	2.Pick up the coils from winding station	123,600	4,800.00	480.00	118,800.00	11,880.00
	3.Flatten the coils by using hydraulic press machines	370,800	211,200.00	21,120.00	159,600.00	15,960.00
3.Trimming	4.Pick up the coils from flattening station	123,600	4,800.00	480.00	118,800.00	11,880.00
	5.Trim the coils by using pneumatic press machines	370,800	312,000.00	31,200.00	58,800.00	5,880.00
4.Forming	6.Bend the coils by using pneumatic press machines	494,400	408,000.00	40,800.00	86,400.00	8,640.00
5.Soldering	7.Pick the coils using pliers and dip the coils into flux	123,600	311.04	62.21	123,288.96	24,657.79
	8. Dip the coils into solder.	123,600	432.00	1,598.40	123,168.00	455,721.60
6.Epoxy application	9. Arrange core on the magnetic strip.	123,600	720,000.00	8,460,000.00	-596,400.00	-7,007,700.00
	10. Put the magnetic strip into the epoxy machine and run the machine.	123,600	544.32	941.67	123,055.68	212,886.33
7.Assembly 1	11.Assemble coil to the I-core	741,600	336,000.00	248,640.00	405,600.00	300,144.00
8.Assembly 2	12. Assemble core with I-core.	494,400	672,000.00	67,200.00	-177,600.00	-17,760.00
9. Oven curing	13.Put the inductor into oven	247,200	3,840,000.00	384,000.00	-3,592,800.00	-359,280.00
10.Boundary inspection	14.The inductors undergo boundary inspection	247,200	240,000.00	24,000.00	7,200.00	720.00
11.Laser marking	15.Put the inductors into laser marking machine	247,200	240,000.00	24,000.00	7,200.00	720.00
12.Co-planarity and VMI	16.Inspect inductors for co-planarity and VMI	247,200	2,496,000.00	1,572,480.00	-2,248,800.00	-1,416,744.00
13.Packaging	17.Pack inductors	247,200	36,000.00	7,200	211,200.00	42,240.00
	Total	4,696,800	9,523,131.07	10,886,842.87	-4,826,331.07	-7,087,378.87

Unused capacity can be obtained by using Equation 3.3. Unused cost on the other hand, is obtained by using Equation 3.4. The total time for the wire to be winded using CNC machine in one month can be represented by χ_1 equals 8,697.6 in 0.12 χ_1, so that

0.12x8697.6 = 1043.71 minutes. When multiplied by capacity cost rate of MYR 2.53, it can be determined that the total cost of this activity is MYR 2,640.59.

Figure 4.2 shows three bar graphs of cost capacity utilization of sub-activities. Based from Table 4.11, this work found that the capacity utilization patterns of 17 sub-activities can be classified into 3 categories which are optimistic, most likely and pessimistic. Optimistic is described as extremely high where the value exceeds the expected result. Whereas most likely is described as moderate and pessimistic is described as negative and undesirable result. The blue bar indicates the total cost of resources while the red bar indicates the unused cost capacity of the sub-activity.

There seven sub-activities classified into optimistic category as shown in Figure 4.2 (a). There are sub-activity 1 (wind wires using CNC machine), sub-activity 2 (pick up the coils from winding station), sub-activity 4 (pick up the coils from flattening station), sub-activity 7 (pick the coils using pliers and dip the coils into flux), sub-activity 8 (dip the coils into solder), sub-activity 10 (put the magnetic strip into the epoxy machine and run the machine), and sub-activity 17 (pack inductors). All seven sub-activities are selected based on their similar pattern.

The pattern of optimistic graph is sub-activities that have no significant difference between total cost of resource and unused cost capacity. From Table 4.8 and Table 4.11, the cost of resource for sub-activity 1 (wind wires using CNC machine) is at MYR 626,449.89 and the unused cost is at MYR 622,775.41. This conveys the message of wastage at the sub-activity due to unused of available resource. In order to overcome this, it is advisable to relocate the operators' sub-activities according to amount of work.

From Figure 4.2 (b), there are six sub-activities grouped into most likely category. There are sub-activity 3 (flatten the coils by using hydraulic press machines), sub-activity 5 (trim the coils by using pneumatic press machines), sub-activity 6 (bend the coils by using pneumatic press machines), sub-activity 11 (assemble coil to the I-core), sub-activity 14 (inductors undergo boundary inspection), and sub-activity 15 (put the inductors into laser marking machine).

The pattern for most likely graph is the significant difference of total cost of resource and unused cost capacity. From Table 4.8 and Table 4.11, the cost of resource of sub-activity 3 (flatten the coils by using hydraulic press machines) is at MYR 36,214 and the unused cost is at MYR 15,960.00. Although there is improvement of most likely category than optimistic category, there is necessity for action to be taken to reduce the amount of unused capacity. However, there are two sub-activities that can be considered to have no waste because the amount of cost difference is within 10% range. The two sub-activities are sub-activity 14 (inductors undergo boundary inspection) and sub-activity 15 (put the inductors into laser marking machine). Therefore, the costs of the two sub-activities are optimized.

From Figure 4.2 (c), there are four sub-activities grouped into pessimistic category. The sub-activities are sub-activity 9 (arrange core on magnetic strip), sub-activity 12 (assemble core with I-core), sub-activity 13 (put inductor into oven) and sub-activity 16 (inspect inductors for co-planarity and then into VMI equipment).

Based on the sub-activities pattern, it is grouped for the similar pattern of having negative value in unused cost. As shown in Table 4.8 and Table 4.11, the total cost of resource of sub-activity 9 (arrange core on magnetic strip) is at MYR 1,452,000 and unused cost is at MYR -7,007,700. The negative values signify the sub-activities have over utilised the resources given. In fact, these sub-activities may have absorbed other sub-activities' resources. It is suggested to add more operators, or to redistribute the work load.

(a)

(b)

(c)

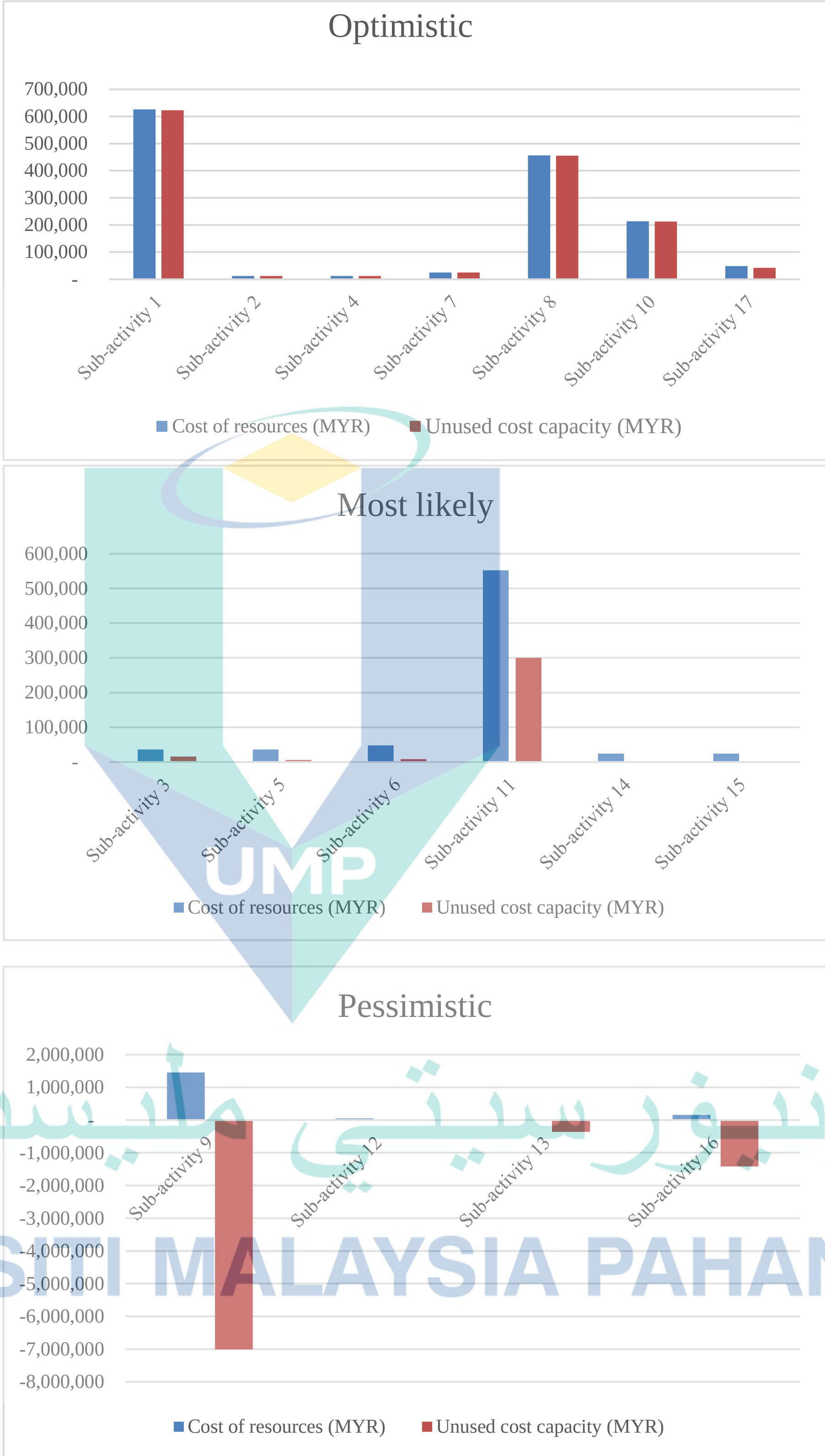

Figure 4.2 Bar graph of cost capacity utilization of sub-activities (a) sub-activity 1,2,4,7,8,10,17; (b) sub-activity 3,5,6,11,14,15; (c) 9,12,13,16

Figure 4.3 shows three bar graphs of time utilization of sub-activities. Based from Table 4.11, this work found that the time utilization patterns of 17 sub-activities can be grouped into 3 categories which are optimistic, most likely and pessimistic. Optimistic is described as extremely high where the value exceeds the expected result. Whereas most likely is described as moderate and pessimistic is described as negative and undesirable result. There are two bars which are green, indicate the total time allocated for a sub-activity. The total time allocated is the practical capacity. The purple bar indicates the unused time of a sub-activity.

There seven sub-activities classified into optimistic category as shown in Figure 4.3 (a). There are sub-activity 1 (wind wires using CNC machine), sub-activity 2 (pick up the coils from winding station), sub-activity 4 (pick up the coils from flattening station), sub-activity 7 (pick the coils using pliers and dip the coils into flux), sub-activity 8 (dip the coils into solder), sub-activity 10 (put the magnetic strip into the epoxy machine and run the machine), and sub-activity 17 (pack inductors).

Being grouped in the optimistic category, the sub-activities are ought to have the same pattern of time allocation. From Figure 4.3 (a), the patterns have minimal differences of practical capacity and unused time. Table 4.11 shows the practical capacity of sub-activity 10 (put the magnetic strip into the epoxy machine and run the machine) is at 123,600 minutes and the time unused is at 123,055.68 minutes. The unused time shows that there is unused amount of time for productivity. It is advisable to relocate the operators' activities according to amount of work to minimize the idle capacity of this sub-activity.

From Figure 4.3 (b), there are six sub-activities grouped into most likely category. There are sub-activity 3 (flatten the coils by using hydraulic press machines), sub-activity 5 (trim the coils by using pneumatic press machines), sub-activity 6 (bend the coils by using pneumatic press machines), sub-activity 11 (assemble coil to the I-core), sub-activity 14 (inductors undergo boundary inspection), and sub-activity 15 (put the inductors into laser marking machine).

The pattern of most likely group in Figure 4.3 (b) shows significant difference between practical capacity and unused time. The practical capacity of sub-activity 11 (assemble coil to the I-core) is 741,600 minutes and the time unused is 405,600 minutes based from Table 4.11. There is 405,600 minutes of unused time that indicates the productivity of this sub-activity can be further enhanced to optimize the unused capacity of time. Unused capacity of time indicates that there are amount of time for operator at the sub-activities that are yet to use. In the contrary, there are two sub-activities that can be considered to have no waste because the difference of time used is within 10% range. The two sub-activities are sub-activity 14 (inductors undergo boundary inspection) and sub-activity 15 (put the inductors into laser marking machine). Therefore, the costs of the two sub-activities are at maximum productivity among other sub-activities.

From Figure 4.3 (c), there are four sub-activities grouped into pessimistic category. The sub-activities are sub-activity 9 (arrange core on magnetic strip), sub-activity 12 (assemble core with I-core), sub-activity 13 (put inductor into oven) and sub-activity 16 (inspect inductors for co-planarity and then into VMI equipment).

Based on the patterns, the sub-activities are grouped because of the similar pattern of having negative value in unused cost. As shown in Table 4.11, the practical capacity of sub-activity 13 (put inductor into oven) is 247,200 minutes and the time unused is -3,592,800 minutes. The negative value of unused time reveals that the operators are overworked. The activities are probably taking more time to be completed. Thus, the implementation of TDABC complied with the second objective which is to appraise the role of capacity cost rate and time equation.

(a)

(b)

(c)

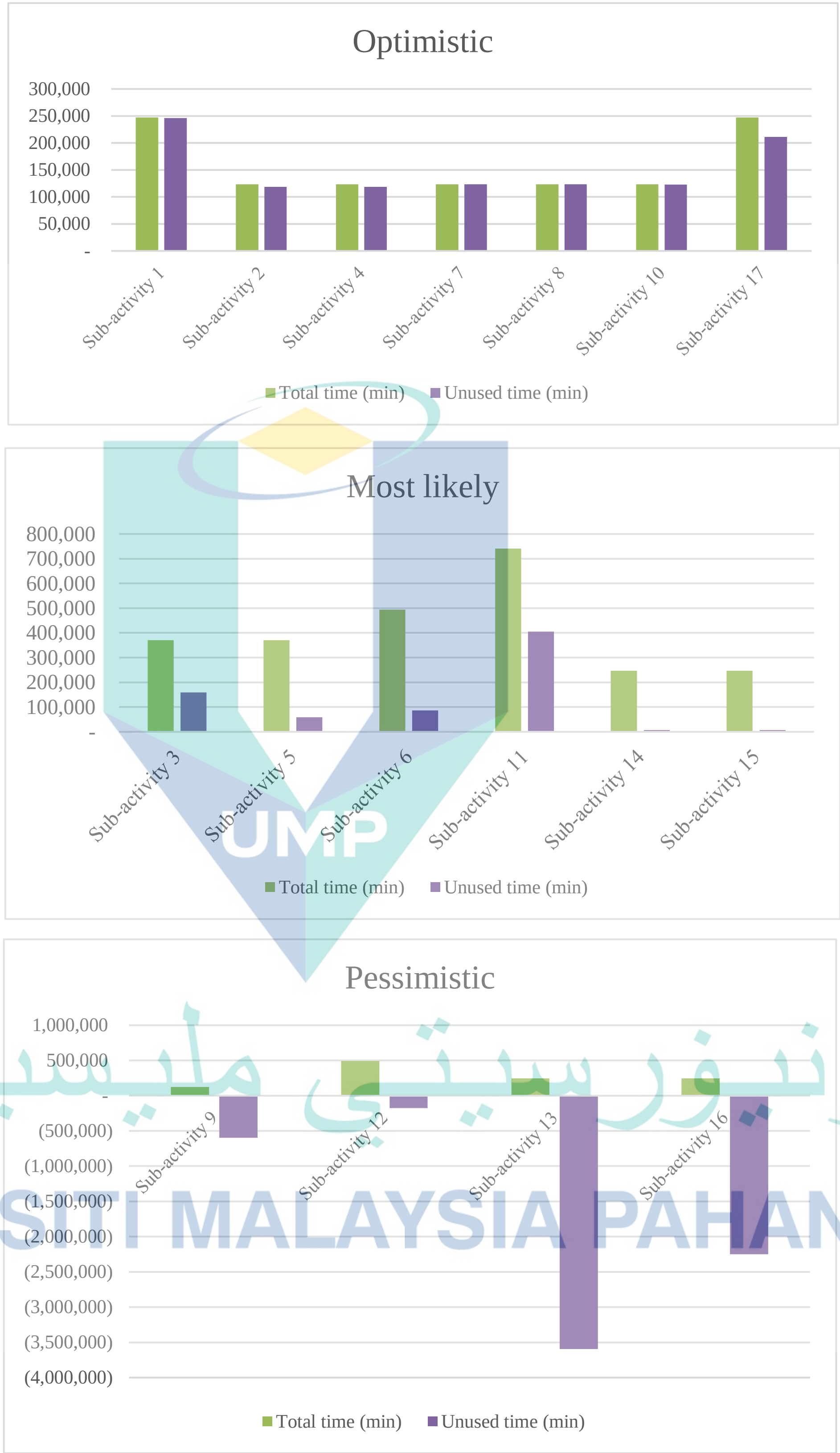

Figure 4.3 Bar graph of duration capacity utilization of sub-activities (a) sub-activity 1,2,4,7,8,10,17; (b) sub-activity 3,5,6,11,14,15; (c) 9,12,13,16

4.15 Comparative study

There are eight features that describe the main differences of ABC and TDABC using data and information that had been gathered at the company. Throughout the discussion, each feature is discussed by highlighting the main differences of ABC followed by TDABC.

4.16 Comparison between ABC and TDABC

There are number of stages for cost allocation in ABC and TDABC, determination of drivers, action taken for an additional activity, cost consideration for implementation, system building, system update, information given from each method, transparency, overestimation of cost, differentiation of service level, oversimplification of activities and capacity forecast and planning. In this chapter, there are eight features to be discussed. There are four features that are abandoned in this discussion which is system building, system update, overestimation of cost and differentiation of service level as the cited paper did not clearly state information regarding the issue.

4.16.1 Cost allocation

Cost allocation is a process of classifying, collecting and assigning cost to cost objects. There are 2 stages in ABC. The first stage allocates the indirect costs to the activity centers and the second stage assigns the allocated costs of these centers to the cost objects, using the activity drivers. Table 4.12 shows direct and indirect cost being allocated to the activity center. There are 13 activities and 4 category of cost which is labor, maintenance, material and consumable. The total of all cost resources supplied for every workstation is MYR 3,795,467.12.

Table 4.12 Labor, maintenance, material and consumable cost for all activities

Workstation	Labor (MYR)	Maintenance (MYR)	Material (MYR)	Consumable (MYR)
1.Winding	24,000.00	26,449.89	576,000.00	nil
2.Flattening	48,000.00	70.00	nil	144.00
3.Trimming	48,000.00	nil	nil	192.00
4.Forming	48,000.00	nil	nil	192.00
5.Soldering	24,000.00	nil	432,000.00	26,024.32
6.Epoxy application	24,000.00	nil	1,641,600.00	129.98
7.Assembly 1	72,000.00	nil	480,000.00	403.20
8.Assembly 2	48,000.00	nil	nil	268.80
9.Oven curing	24,000.00	nil	nil	24.00
10.Boundary inspection	24,000.00	nil	nil	134.40
11.Laser marking	24,000.00	626.53	nil	nil
12.Co-planarity and VMI	24,000.00	nil	nil	130,824.00
13.Packaging	24,000.00	nil	nil	24,384.00
Total	MYR 456,000.00	MYR 27,146.42	MYR 3,129,600.00	MYR 182,720.70

Next, the second stage, it is to assign activity center to cost object. It is shown in Table 4.13, where cost driver rate is calculated with respect to the activity center.

Table 4.13 Cost driver rates for activities

Activity	Cost driver	Cost of resources supplied (MYR)	Cost driver quantity	Cost driver rate (MYR)
11. Laser marking	Laser marking machine (frequency)	24,626.53	4,800,000	0.01
12. Co-planarity and VMI	Inspection (frequency)	154,824.00	4,800,000	0.03
13. Packaging	Product items (quantity)	48,384.00	4,800,000	0.01

As for TDABC, the allocation of cost is in one stage. In TDABC, total time taken is used to allocate cost to the activities. Table 4.14 shows an activity, the usage of time and cost to complete the work. The usage of time for winding is 1,043.71 minutes with total cost of MYR 2,640.59. The total cost of winding with respect to time is related to information in Table 4.17.

Table 4.14 Capacity utilization of TDABC

Activity	Sub-activities	Practical capacity	Used time (min)	Total cost (RM)	Unused time (min)	Unused cost (MYR)
1.Winding	1.Wind wires using CNC machine	247,200	1,043.71	2,640.59	246,156.29	622,775.41

The usage of time as mention in Table 4.14 is derived from information from Table 4.15 and Table 4.16. In Table 4.16, the standard of time for winding activity is shown which is 0.12 minutes. χ_1 is the variable of time of this activity.

Table 4.15 Standard time of winding activity

Activity	Sub-activities	Time equations
1.Winding	1. The wire are winded using CNC machine	$0.12\chi_1$

In Table 4.16 shows the information describing the time variable in winding activity. The time variable is the quantity of the driver which is 8,697.6 kg.

Table 4.16 Time variable of winding activity

Activity	Var.	Sub-activities	Driver	Quantity/year
1.Winding	χ_1	1. The wire are winded using CNC machine	Amount of raw material (kg)	8,697.6

In terms of cost in TDABC, Table 4.17 shows the total cost of resources supplied for winding activity which is MYR 626,449.89. The given practical capacity is 247,200 minutes. By using the information gained, capacity cost rate for winding activity is generated as much as MYR 2.53. The capacity cost rate is used to generate total cost in the activity as in Table 4.14. The total cost for winding is MYR 2,644.96.

Table 4.17 Capacity cost rate for winding activity

Activity	Sub-activities	Cost of all resources supplied (MYR) [1]	Practical capacity (min) [2]	Capacity cost rate (MYR) [1]/[2]=[3]
1. Winding	1. The wire are winded using CNC machine	626,449.89	247,200	2.53

Indeed, the TDABC allocates cost in one stage where the process is connected directly to the time and cost with respect to the activity itself.

4.16.2 The determination of driver

Cost driver is the activity that contributes the most of cost in an activity. Both ABC and TDABC have drivers in the costing but are determined with different method. For ABC, the driver is determined by the time allocated per activity as in Table 4.18. The time allocated for flattening activity is 1.27% of all 13 activities identified in ABC. The time allocated by operator to complete the task given is identified through surveying. The time allocation is collected as an average, by interview session and by observation at the workstation.

Table 4.18 Percentage of time allocation for flattening activity

Activity	Time allocation (%)
Flattening	1.27

While TDABC treats each activity using a time driver and does not determine the activity driver according to the property of that activity, as is the case with ABC. Table 4.19 demonstrates flattening and the sub-activities occur at the workstation with standard time and variables. There are two sub-activities in this workstation, therefore two equations produced which is 10.00 χ_2 and 0.22 χ_3.

Table 4.19 Standard time and variable for flattening activity

Activity	Sub-activities	Time equations
Flattening	1. Pick up the coils from winding station	10.00 χ_2
	2. Flatten the coils by using hydraulic press machines	0.22 χ_3

In Table 4.20, the variable for flattening activity is described. To produce the time equations, the value of χ_2 and χ_3 is substitute with quantity of 480 and 960,000 respectively.

Table 4.20 Variables of flattening activity

Var.	Driver	Quantity/year
χ_2	1. Pick up the coils from winding station	480
χ_3	2.0Flatten the coils by using hydraulic press machines	960,000

Thus, the determination of driver in ABC and TDABC is different that the driver in ABC is subjective to the time estimations through surveying process. The determination of driver in TDABC is objective because it uses the time equations with respect to each activity and sub-activity.

4.16.3 Consideration of an additional activity

Additional activity is any new activity added to the production line. ABC and TDBC act differently when there is an additional activity in the production line. For ABC, this method needs to do a thorough resurvey on the activities that involved with the additional activity. Additional activity affects time allocation for all workstation as shown in Table 4.21, when a new activity is added, the total percentage of time allocation changes.

Table 4.21 Percentage of time allocation in ABC

Activity	**Time allocation (%)**
Flattening	1.27
xxxxxx	xxxxxx

With TDABC, when a new activity is added, only the unit time for the new activity must be estimated and a thorough subsequent resurvey, which is the case for ABC, is avoided. Once a new activity is added, a new time and variable is added to the original equation as shown in Equation 4.2.

$$T_{\text{sub-activities}} = 0.12\chi_1 + 10.00\chi_2 + 0.22\chi_3 + 10.00\chi_4 + XXXXXX + 0.13\chi_5 + 0.17\chi_6 + 0.72\chi_7 + 0.18\chi_8 + 0.15\chi_9 + 2.7\chi_{10} + 0.07\chi_{11} + 0.14\chi_{12} + 0.8\chi_{13} + 0.05\chi_{14} + 0.05\chi_{15} + 0.52\chi_{16} + 3.00\chi_{17} \quad 4.2$$

Therefore, with TDABC, the process is simpler and removes time consuming process.

4.16.4 Cost consideration

This topic is focusing on cost consideration of steps in ABC and TDABC. In ABC, for every workstation, the time allocated by operators to complete the task given is identified. The time allocation is collected as an average, by interviewing the operators and by observation. In Table 4.23, it is shown the time allocation for winding activity which is 16.51% of all other 12 activities. This is the result from the surveying process.

Table 4.22 Time allocation for winding activity

Activity	**Time allocation (%)**
Winding	16.51

In TDABC, it simplifies the costing process by skipping the possible interviews or surveys made to the employees for allocating the resource costs to the activities. In this manner, TDABC avoids the costly, time-consuming, and subjective activity-surveying task of ABC (Kaplan & Anderson, 2007). Thus, TDABC allows employees to concentrate more on the production time, so that the company gains a sustainable competitive advantage. This benefits manufacturers, especially as industry is now going through a low-margin era.

4.16.5 Informative

A system is considered informative when it is able to deliver useful or interesting information. It is understood that a method is more informative than the other when it offers more information to the management especially in terms of capacity utilization. In ABC, cost driver information is highlighted as it is used as rate and to forecast the product cost. It is beneficial to the company for decision making in the future.

By using time equation and capacity cost rate, the capacity utilization analysis can be done. This is useful as it delivers information of efficiency and productivity of every activity and sub-activity. Therefore, TDABC can benchmark the efficiency of production activities and gives more information about the idle capacity.

4.16.6 Transparency

Transparency is an ability to show in detail the duration of an activity. ABC and TDABC both have time allocated for the activities but differ in the method to display the time needed. Table 4.23 displays the time equation for trimming activity, 10.00 χ_4 and 0.13 χ_5.

Table 4.23 Time equations of TDABC

Activity	Sub-activities	Time equations
Trimming	1. Pick up the coils from flattening station	10.00 χ_4
	2. Trim the coils by using pneumatic press machines	0.13 χ_5

The value of χ_4 and χ_5 are substitute with the value in Table 4.24 which are 480 and 2,400,000 respectively.

Table 4.24 Variables of time in TDABC

Var.	Driver	Quantity/year
χ_4	Pick up the coils from flattening station (rounds)	480
χ_5	Number of pneumatic press machine operating (frequency/month)	2,400,000

Eventually, in Table 4.25, the used and unused time of the activities are obtained. For sub-activity 2 in trimming activity, there is amount of 312,000 minutes of used time and 58,800 minutes of unused time. Thus, TDABC is able to portray transparency better than ABC in showing duration of time for activities.

Table 4.25 Used time and unused time in TDABC

Sub-activities	Used time (min)	Unused time (min)
1. Pick up the coils from flattening station	4,800	118,800
2. Trim the coils by using pneumatic press machines	312,000	58,800

However, (Liu & Gong, 2011) stated that ABC is transparent. The method uses cost drivers to allocate indirect costs to products, thus the method is transparent.

4.16.7 Oversimplification of activities

For oversimplification of activity feature, it will be discuss in term of the number of driver used. ABC assumes that each activity uses a single cost driver, but in practice, an activity can have multiple cost drivers. In contrast, TDABC can use multiple cost drivers, in the form of time drivers, for an activity. In Table 4.26, ABC assumes single cost driver for soldering.

Table 4.26 Cost driver for soldering

Activity	Cost driver
Soldering	Amount of material used (g)

On the contrary, as shown in Table 4.27, TDABC uses more than one cost driver for soldering activity. There are two drivers which are amount of flux and amount of solder used.

Table 4.27 Variations cost driver of solder activity

Var.	Driver	Quantity/year
χ_7	Amount of flux used (litre)	432
χ_8	Amount of solder used (kg)	2,400

4.16.8 Capacity forecast and planning

Forecast and planning step is crucial as it predicts the future action and scenario. This step needs to be amplified with convincing data of the current situation. Both ABC and TDBAC have the ability to forecast however, the depth of the information sets a level between the two methods. For example, ABC is able to forecast using cost driver rates to determine the product unit cost. The company would have insight of appropriate cost and price for future references. According to Figure 4.4, the forecast product unit cost is generated in percentage for each activity.

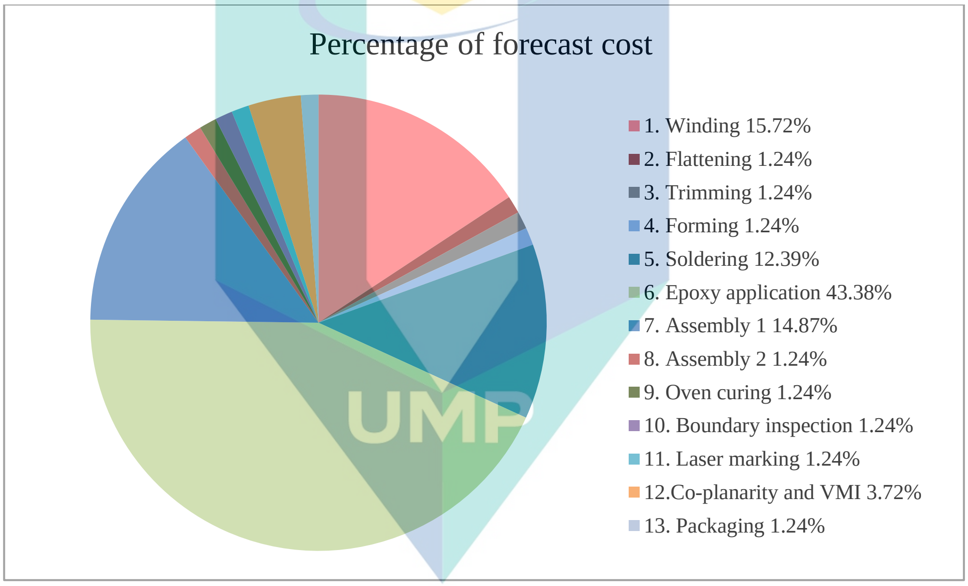

Figure 4.4 Percentage of forecast cost

As for TDABC, Figure 4.5 displays the details of co-planarity and VMI activity. It shows information of used and unused time and cost. The sub-activity is to inspect inductors for co-planarity and VMI and has used time of 2,496,000 minutes and unused time of -2,248,800 minutes. TDABC separates the used resources and unused resources. By doing that, TDABC gained knowledge on the performance of each activity. In TDABC, forecast can be done using reference of capacity utilization. Therefore, TDABC can be point of reference for efficiency of production activities and provides evidence about the idle capacity.

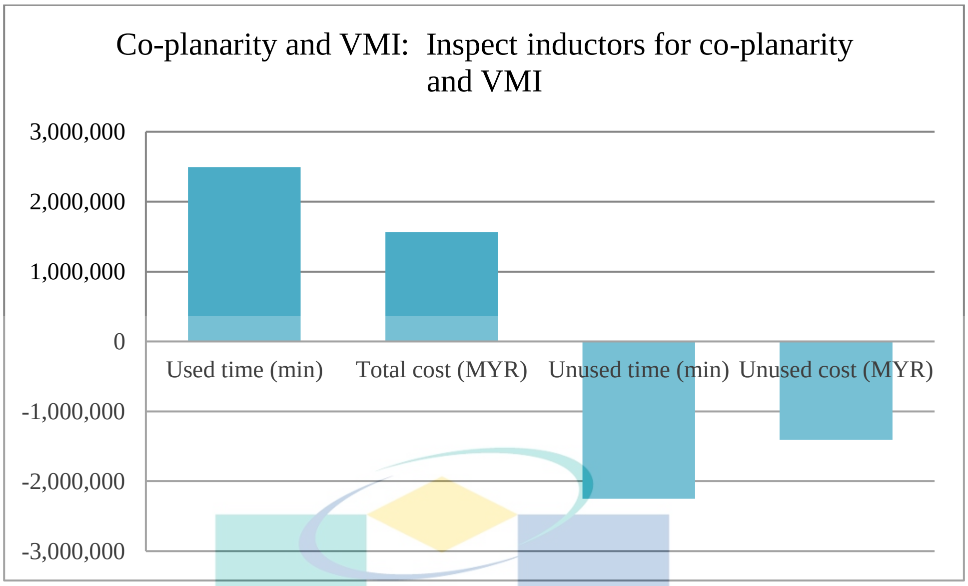

Figure 4.5 Capacity utilization of co-planarity and VMI activity

In conclusion, by implementing and comparing of ABC and TDABC at the company, this work proves TDABC is a method with objective cost driver determination, removes time consuming process, have multiple cost drivers and able to forecast and planning using analysis of capacity utilization. On the other hand, ABC is a transparent method and the method can forecast unit product cost by using cost driver rate. Therefore, the comparative study complied with the third objective which is to compare ABC and TDABC costing sustainment by using the features.

4.17 Summary

This chapter elaborates the details on implementing ABC and TDABC in an electrical and electronics production company. Through implementation of ABC, the cost drivers of every activity is highlighted. The cost driver and cost driver rate are important in determining forecast for product unit. Through implementation of TDABC, the role of capacity cost rate and time equations are pointed out. Capacity cost rate and time equations are crucial for the capacity utilization analysis. Capacity utilization delivers information of productivity of the activities. Through comparative study of ABC and TDABC, it is concluded that TDABC is a method that have objective cost driver determination, removes time consuming process, have multiple cost drivers and able to forecast and planning using analysis of capacity utilization.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This chapter concludes the implementation of Activity-based Costing (ABC) and Time-driven Activity-based Costing (TDABC) as well as the comparative study of both method. The recommendations and suggestions are also provided for future exploration.

5.1.1 Conclusion of ABC implementation

The following are the conclusions of this research on ABC:

- This work gathered the time allocated by operator to complete the task given as shown in Table 4.1. The largest time allocated by operators is at epoxy application activity which is 43.89% and the smallest time allocated by the operators is 0.63% at oven curing. This time estimation has been validated by the Industrial Engineer.

- The cost of capacity is calculated for every activity and it is obtained that epoxy application activity has the highest amount of cost of MYR 1,665,729.98. This amount is obtained by summation of labor, maintenance, material and consumable cost of the activity.

- The cost driver of the production line as shown in Table 4.3. For example cost driver for oven curing activity is clipping process and cost driver for boundary inspection activity is product item. This time estimation has been validated by the engineer.

- As the demand quantity of the product is increase by 10%, the total cost of production is predicted to be MYR 4,260,115.20 while the unit product cost is forecast at MYR 0.81.

- It is discovered that the company applied their costing on activity based rather than volume based. Lead time for each workstation is used to generate the product cost. The company may have implemented the costing using activity based however, the cost drivers are not significantly pointed out. Meanwhile, ABC method is able to point out cost drivers.

- This work is able to show that the implementation of ABC benefits the company by pointing out the cost drivers of every activity. The cost driver and cost driver rate are important in determining forecast for product unit. Therefore, this work answered the research question and achieved the first objective.

5.1.2 Conclusion of TDABC implementation

The following are the conclusions of this research on TDABC:

- This work identified 17 sub-activities for all 13 activities in the production of magnetic inductor. The cost of resource supplied to this production is further detailed according to the sub-activities as shown in Table 4.7.

- The capacity cost rate for each activity is calculated using the value of practical capacity and cost of resource supplied as shown in Table 4.8. Therefore, the practical capacity per year is 123,600 minutes for every operator. Both information of capacity cost rate and practical capacity will be used to generate capacity utilization as shown in Table 4.11.

- The standard time and variable for every activity and sub-activity is concluded in Table 4.9 and Table 4.10. For example, for packaging activity the standard time is 3.00 minutes with variable of χ_{17}; 12,000.

- The capacity utilization is shown as in Table 4.11. The total time is the practical capacity which is 123,600 minutes for sub-activity 7 while the unused time is 123,288.96 minutes. As for cost capacity, the total cost assigned is MYR 24,960 and the unused capacity cost is MYR 24,657.79. Unused capacity indicates that there is amount of time for operator at the sub-activity that is yet to use.

- From capacity utilization analysis, there are seven sub-activities categorized as optimistic, another six sub-activities categorized as most likely and four sub-activities classified as pessimistic.

- From the implementation of TDABC, this work is able to appraise the role of capacity cost rate and time equations. Capacity cost rate and time equations are vital for the capacity utilization analysis. Therefore, this work is able to answer the research question and achieved the second objective.

5.1.3 Comparative study

The following are the conclusions of this research on comparative study of ABC and TDBC:

- Cost allocation is a process of classifying, collecting and assigning cost to cost objects. TDABC allocates cost in one stage where the process is connected directly to the time and cost with respect to the activity itself. Table 4.14 shows an activity, the usage of time and cost to complete the work. The usage of time for winding is 1,043.71 minutes with total cost of MYR 2,640.59.

- Cost driver is the activity that contributes the most of cost in an activity. TDABC treats each activity using a time driver and does not determine the activity driver according to the property of that activity. Table 4.19 demonstrates flattening and the sub-activities occur at the workstation with standard time and variables. There are 2 sub-activities in this workstation; therefore, two equations produced which is 10.00 χ_2 and 0.22 χ_3.

- Additional activity is any new activity added to the production line. With TDABC, when a new activity is added, only the unit time for the new activity must be estimated and a thorough subsequent resurvey is avoided. Once a new activity is added, a new time and variable is added to the original equation as shown in Equation 4.2. Therefore, with TDABC, the process is simpler and removes time consuming process.

- Moreover, TDABC simplifies costing process by skipping possible interviews or surveys made to the employees to allocate resource costs to the activities. By that, TDABC manages to avoid a costly and time-consuming process. Thus, TDABC allows employees to concentrate more on the production time, so that the company gains a sustainable competitive advantage.

- It is understand that a method is more informative than the other when it offers more information to the management especially in terms of capacity utilization. By using time equation and capacity cost rate, the capacity utilization analysis can be completed. Therefore, TDABC can benchmark the efficiency of production activities and gives more information about the idle capacity.

- Transparency is the ability to show in detail the duration of an activity. Table 4.23 displays the time equation for trimming activity, 10.00 χ_4 and 0.13 χ_5 .The value of χ_4 and χ_5 are substitute with the value in Table 4.24 which is 480 and 2,400,000 respectively. In Table 4.25, the used and unused time of the activities are obtained. For sub-activity 2, there is amount of 312,000 minutes of used time and 58,800 minutes of unused time. Thus, TDABC is able to portray transparency better than ABC in showing duration of time for activities.

- Furthermore, TDABC can use multiple cost drivers, in the form of time drivers, for an activity. As shown in Table 4.27, TDABC uses more than one cost driver for soldering activity. There are two drivers which are amount of flux and amount of solder used.

- Forecast and planning step predicts the future action and scenario. Figure 4.5 portrays the details of co-planarity and VMI activity. It shows information of used and unused time and cost. The activity has used time of 2,496,000 minutes and unused time of -2,248,800 minutes. TDABC separates the used resources and unused resources. By doing that, TDABC successfully gained knowledge on the performance of each activity.

- In conclusion of this comparative study, the implementation of TDABC benefits the company by having objective cost driver determination, removes time consuming process, have multiple cost drivers and able to forecast and planning using analysis of capacity utilization. Thus, this work manages to answer the research question and achieved the third objective which is to compare ABC and TDABC based on analysing the features towards costing sustainment.

5.2 Recommendation

The followings are the recommendations for future study:

- This work is done in a manufacturing environment specifically at an electric and electronic production company. The result of this work is reliable and accurate to compare with the same industry. Every industry has different behaviour. Therefore, to gain more knowledge on how ABC and TDABC implementations at other industries, it is recommended to have further studies in different industries such as textile or service.

- This research contributes to the understandings of the production capacity utilization. However, the research is limited to only two methods which are ABC and TDABC. In the vast diversity in industry, there are a lot of other methods and there is necessity to conclude which method is best to complement with certain industry or specific problem. Hence, to gain better accuracy, further exploration on the usage of algorithms such as hybrid-meta-heuristics is recommended.

REFERENCES

Abu, M. Y., Jamaludin, K. R., & Zakaria, M. A. (2017). Characterisation of activity based costing on remanufacturing crankshaft. *Journal, International Issn, Mechanical Engineering Publishing, Pahang, 14*(2), 4211–4224. https://doi.org/10.15282/ijame.14.2.2017.8.0337

Abu, M. Y., Mohd Nor, E. E., & Abd Rahman, M. S. (2018). Costing improvement of remanufacturing crankshaft by integrating Mahalanobis-Taguchi System and Activity based Costing. *IOP Conference Series: Materials Science and Engineering, 342*, 12006. https://doi.org/10.1088/1757-899x/342/1/012006

Adane, K., Abiy, Z., & Desta, K. (2015). The revenue generated from clinical chemistry and hematology laboratory services as determined using activity-based costing (ABC) model. *Cost Effectiveness and Resource Allocation, 13*(1), 1–7. https://doi.org/10.1186/s12962-015-0047-7

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*(5), 1003–1019. https://doi.org/10.3926/jiem.2086

Akhavan, S., Ward, L., & Bozic, K. J. (2016). Time-driven Activity-based Costing More Accurately Reflects Costs in Arthroplasty Surgery. *Clinical Orthopaedics and Related Research*, *474*(1), 8–15. https://doi.org/10.1007/s11999-015-4214-0

Alaoui, S. El, & Lindefors, N. (2016). Combining time-driven activity-based costing with clinical outcome in cost-effectiveness analysis to measure value in treatment of depression. *PLoS ONE*, *11*(10), 1–15. https://doi.org/10.1371/journal.pone.0165389

Allain, E., & Laurin, C. (2018). Explaining implementation difficulties associated with activity-based costing through system uses. *Journal of Applied Accounting Research*, *19*(1), 181–198. https://doi.org/10.1108/JAAR-11-2014-0120

Almeida, A., & Cunha, J. (2017). The implementation of an Activity-Based Costing (ABC) system in a manufacturing company. *Procedia Manufacturing*, *13*, 932–939. https://doi.org/10.1016/j.promfg.2017.09.162

Alsmadi, M., Almani, A., & Khan, Z. (2014). Quality paper implementing an integrated ABC and TOC approach to enhance decision making in a lean context a case study. *International Journal of Quality and Reliability Management*, *31*(8), 906–920. https://doi.org/10.1108/IJQRM-04-2013-0063

Andreasen, S. E., Holm, H. B., Jørgensen, M., Gromov, K., Kjærsgaard-Andersen, P., & Husted, H. (2017). Time-driven Activity-based Cost of Fast-Track Total Hip and Knee Arthroplasty. *Journal of Arthroplasty*, *32*(6), 1747–1755. https://doi.org/10.1016/j.arth.2016.12.040

Anzai, Y., Heilbrun, M. E., Haas, D., Boi, L., Moshre, K., Minoshima, S., … Lee, V. S. (2017). Dissecting Costs of CT Study: Application of TDABC (Time-driven

Activity-based Costing) in a Tertiary Academic Center. *Academic Radiology*, *24*(2), 200–208. https://doi.org/10.1016/j.acra.2016.11.001

Avansino, J., Libby, A., Murphy, W., Melzer, L., Waldhausen, J., & Merguerian, P. (2014). Optimizing Value Utilizing Toyota Kata Methodology in a Multidisciplinary Clinic. In *Journal of Pediatric Urology* (Vol. 11). https://doi.org/10.1016/j.jpurol.2015.05.010

Azar, N., Leblond, V., Ouzegdouh, M., & Button, P. (2017). A transition from using multi-step procedures to a fully integrated system for performing extracorporeal photopheresis: A comparison of costs and efficiencies. *Journal of Clinical Apheresis*, *32*(6), 474–478. https://doi.org/10.1002/jca.21542

Bagherpour, M., Nia, A. K., Sharifian, M., & Mazdeh, M. M. (2013). Time-driven activity-based costing in a production planning environment. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *227*(2), 333–337. https://doi.org/10.1177/0954405412464484

Barros, R. S., & Da Costa Ferreira, A. M. D. S. (2017). Time-driven activity-based costing : Designing a model in a Portuguese production environment. *Qualitative Research in Accounting and Management*, *14*(1), 2–20. https://doi.org/10.1108/QRAM-10-2015-0095

Bauer-Nilsen, K., Hill, C., Trifiletti, D. M., Libby, B., Lash, D. H., Lain, M., … Showalter, T. N. (2018). Evaluation of Delivery Costs for External Beam Radiation Therapy and Brachytherapy for Locally Advanced Cervical Cancer Using Time-Driven Activity-Based Costing. *International Journal of Radiation Oncology Biology Physics*, *100*(1), 88–94. https://doi.org/10.1016/j.ijrobp.2017.09.004

Beriwal, S., & Chino, J. (2018). Time-Driven Activity-Based Costing in Oncology: A Step in the Right Direction. *International Journal of Radiation Oncology Biology Physics*, *100*(1), 95–96. https://doi.org/10.1016/j.ijrobp.2017.10.017

Burnett, L., Wilson, R., Pfeffer, S., Lowry, J., & Bipac. (2012). Benchmarking in pathology: Development of an activity-based costing model. *Pathology*, *44*(7), 644–653. https://doi.org/10.1097/PAT.0b013e32835a9ec4

Campanale, C., Cinquini, L., & Tenucci, A. (2014). Time-driven activity-based costing to improve transparency and decision making in healthcare A case study. *Qualitative Research in Accounting and Management*, *11*(2), 165–186. https://doi.org/10.1108/QRAM-04-2014-0036

Cannavacciuolo, L., Iandoli, L., Ponsiglione, C., & Zollo, G. (2012). An analytical framework based on AHP and activity-based costing to assess the value of competencies in production processes. *International Journal of Production Research*, *50*(17), 4877–4888. https://doi.org/10.1080/00207543.2012.657974

Cannavacciuolo, L., Illario, M., Ippolito, A., & Ponsiglione, C. (2015). An activity-based costing approach for detecting inefficiencies of healthcare processes. *Business Process Management Journal*, *21*(1), 55–79. https://doi.org/10.1108/BPMJ-11-

2013-0144

Carli, G., & Canavari, M. (2013). Introducing Direct Costing and Activity based Costing in a Farm Management System: A Conceptual Model. *Procedia Technology*, *8*(Haicta), 397–405. https://doi.org/10.1016/j.protcy.2013.11.052

Cassettari, L., Mosca, M., Mosca, R., Rolando, F., Costa, M., & Pisaturo, V. (2016). IVF cycle cost estimation using Activity Based Costing and Monte Carlo simulation. *Health Care Management Science*, *19*(1), 20–30. https://doi.org/10.1007/s10729-014-9282-2

Chen, A., Sabharwal, S., Akhtar, K., Makaram, N., & Gupte, C. M. (2015). Time-driven activity based costing of total knee replacement surgery at a London teaching hospital. *Knee*, *22*(6), 640–645. https://doi.org/10.1016/j.knee.2015.07.006

Chouhan, V., Soral, G., & Chandra, B. (2017). Activity based costing model for inventory valuation. *Management Science Letters*, *7*, 135–144. https://doi.org/10.5267/j.msl.2016.12.003

Crott, R., Lawson, G., Nollevaux, M. C., Castiaux, A., & Krug, B. (2016). Comprehensive cost analysis of sentinel node biopsy in solid head and neck tumors using a time-driven activity-based costing approach. *European Archives of Oto-Rhino-Laryngology*, *273*(9), 2621–2628. https://doi.org/10.1007/s00405-016-4089-z

Cugini, A., Michelon, G., & Pilonato, S. (2013). Innovating cost accounting practices in rail transport companies. *Journal of Applied Accounting Research*, *14*(2), 147–164. https://doi.org/10.1108/09675421311291892

Da Silva Medeiros, H., Santana, A. F. B., & Da Silva Guimarães, L. (2017). The use of costing methods in Lean Manufacturing industries: A literature review. *Gestao e Producao*, *24*(2), 395–406. https://doi.org/10.1590/0104-530X2183-16

Dessureault, S., & Benito, R. O. (2012). Data mining and activity based costing for equipment replacement decisions Part 1 – establishing the information infrastructure. *Mining Technology*, *121*(2), 73–82. https://doi.org/10.1179/1743286312Y.0000000003

Devji, T. F., Madenci, A. L., Carpino, E., Leahy, I. C., Samnaliev, M., Dearden, J. L., … Cravero, J. (2016). Safety and cost-effectiveness of port removal outside of the operating room among pediatric patients. *Journal of Pediatric Surgery*, *51*(11), 1891–1895. https://doi.org/10.1016/j.jpedsurg.2016.07.017

Erhun, F., Mistry, B., Platchek, T., Milstein, A., Narayanan, V. G., & Kaplan, R. S. (2015). Time-driven activity-based costing of multivessel coronary artery bypass grafting across national boundaries to identify improvement opportunities: Study protocol. *BMJ Open*, *5*(8), 1–8. https://doi.org/10.1136/bmjopen-2015-008765

Esmalifalak, H., Albin, M. S., & Behzadpoor, M. (2015). A comparative study on the activity based costing systems: Traditional, fuzzy and Monte Carlo approaches. *Health Policy and Technology*, *4*(1), 58–67.

https://doi.org/10.1016/j.hlpt.2014.10.010

Fang, Y., & Ng, S. T. (2011). Applying activity-based costing approach for construction logistics cost analysis. *Construction Innovation*, *11*(3), 259–281. https://doi.org/10.1108/14714171111149007

Feng, S., & Ho, C. Y. (2016). The real option approach to adoption or discontinuation of a management accounting innovation: the case of activity-based costing. *Review of Quantitative Finance and Accounting*, *47*(3), 835–856. https://doi.org/10.1007/s11156-015-0522-4

Fito, M. A., Llobet, J., & Cuguero, N. (2018). The activity-based costing model trajectory: A path of lights and shadows. *Intangible Capital*, *14*(1), 146–161. https://doi.org/10.3926/ic.1107

French, K. E., Albright, H. W., Frenzel, J. C., Incalcaterra, J. R., Rubio, A. C., Jones, J. F., & Feeley, T. W. (2013). Measuring the value of process improvement initiatives in a preoperative assessment center using time-driven activity-based costing. *Healthcare*, *1*(3–4), 136–142. https://doi.org/10.1016/j.hjdsi.2013.07.007

French, K. E., Guzman, A. B., Rubio, A. C., Frenzel, J. C., & Feeley, T. W. (2016). Value based care and bundled payments: Anesthesia care costs for outpatient oncology surgery using time-driven activity-based costing. *Healthcare*, *4*(3), 173–180. https://doi.org/10.1016/j.hjdsi.2015.08.007

Goense, L., van Dijk, W. A., Govaert, J. A., van Rossum, P. S. N., Ruurda, J. P., & van Hillegersberg, R. (2017). Hospital costs of complications after esophagectomy for cancer. *European Journal of Surgical Oncology*, *43*(4), 696–702. https://doi.org/10.1016/j.ejso.2016.11.013

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

Govaert, J. A., Van Dijk, W. A., Fiocco, M., Scheffer, A. C., Gietelink, L., Wouters, M. W. J. M., & Tollenaar, R. A. E. M. (2016). Nationwide Outcomes Measurement in Colorectal Cancer Surgery: Improving Quality and Reducing Costs Presented at the European Society of Surgical Oncology 34thCongress, Liverpool, United Kingdom, October 2014. *Journal of the American College of Surgeons*, *222*(1), 19-29.e2. https://doi.org/10.1016/j.jamcollsurg.2015.09.020

Grant, P. (2015). How much does a diabetes out-patient appointment actually cost? An argument for PLICS. *Journal of Health, Organisation and Management*, *29*(2), 154–169. https://doi.org/10.1108/JHOM-01-2012-0005

Greasley, A., & Smith, C. M. (2017). Using activity-based costing and simulation to reduce cost at a police communications centre. *Policing*, *40*(2), 426–441. https://doi.org/10.1108/PIJPSM-03-2016-0044

Gregorio, L. T. Di, & Soares, C. A. P. (2013). Comparison between the Mix-Based Costing and the Activity-Based Costing Methods in the Costing of Construction

Projects. *Journal of Cost Analysis and Parametrics*, *6*(2), 77–95. https://doi.org/10.1080/1941658X.2013.843418

Gregório, J., Russo, G., & Lapão, L. V. (2016). Pharmaceutical services cost analysis using time-driven activity-based costing: A contribution to improve community pharmacies' management. *Research in Social and Administrative Pharmacy*, *12*(3), 475–485. https://doi.org/10.1016/j.sapharm.2015.08.004

Haas, D. A., & Kaplan, R. S. (2017). Variation in the cost of care for primary total knee arthroplasties. *Arthroplasty Today*, *3*(1), 33–37. https://doi.org/10.1016/j.artd.2016.08.001

Hamid, K. S., Matson, A. P., Nwachukwu, B. U., Scott, D. J., Mather, R. C., & Deorio, J. K. (2017). Determining the Cost-Savings Threshold and Alignment Accuracy of Patient-Specific Instrumentation in Total Ankle Replacements. *Foot and Ankle International*, *38*(1), 49–57. https://doi.org/10.1177/1071100716667505

Haroun, A. E. (2015). Maintenance cost estimation: application of activity-based costing as a fair estimate method. *Journal of Quality in Maintenance Engineering*, *21*(3), 258–270. https://doi.org/10.1108/JQME-04-2015-001

Helmers, R. A., Dilling, J. A., Chaffee, C. R., Larson, M. V., Narr, B. J., Haas, D. A., & Kaplan, R. S. (2017). Overall Cost Comparison of Gastrointestinal Endoscopic Procedures With Endoscopist- or Anesthesia-Supported Sedation by Activity-Based Costing Techniques. *Mayo Clinic Proceedings: Innovations, Quality & Outcomes*, *1*(3), 234–241. https://doi.org/10.1016/j.mayocpiqo.2017.10.002

Hofmann, E., & Bosshard, J. (2017). Supply chain management and activity-based costing: Current status and directions for the future. *International Journal of Physical Distribution and Logistics Management*, *47*(8), 712–735. https://doi.org/10.1108/IJPDLM-04-2017-0158

Huang, J., & Li, S. (2011). The research of environmental costs based on activity based cost. *Procedia Environmental Sciences*, *10*(PART A), 147–151. https://doi.org/10.1016/j.proenv.2011.09.026

Husby, K. R., Tolstrup, C. K., Lose, G., & Klarskov, N. (2018). Manchester–Fothergill procedure versus vaginal hysterectomy with uterosacral ligament suspension: an activity-based costing analysis. *International Urogynecology Journal*, *29*(8), 1161–1171. https://doi.org/10.1007/s00192-018-3575-9

Ibrahim, R., Nur, A. M., Hassan, N. H., Am, H., & Aljunid, S. M. (2014). The cost of radiological procedures at Universiti Kebangsaan Malaysia Medical Centre: applying activity based costing methodology. *BMC Public Health*, *14*(Suppl 1), O21. https://doi.org/10.1186/1471-2458-14-S1-O21

Intakhan, P. (2014). ABC success: Evidence from ISO 9000 certified companies in Thailand. *Asian Review of Accounting*, *22*(3), 287–303. https://doi.org/10.1108/ARA-06-2013-0044

Kaplan, R. S., & Johnson, H. T. (1987). Relevance Lost: The Rise and Fall of Management Accounting. *Boston: Harvard Business School Press*.

Kaplan, A. L., Agarwal, N., Setlur, N. P., Tan, H. J., Niedzwiecki, D., McLaughlin, N., … Saigal, C. S. (2015). Measuring the cost of care in benign prostatic hyperplasia using time-driven activity-based costing (TDABC). *Healthcare*, *3*(1), 43–48. https://doi.org/10.1016/j.hjdsi.2014.09.007

Kaplan, R. S., & Anderson, S. R. (2007). *Time-Driven Activity-Based Costing: A Simpler and More Powerful Path to Higher Profits*. Boston: Harvard Business School Press.

Kaplan, R. S., Cooper, R., Maisel, L., Morrissey, E., & Oehm, R. M. (1992). Implementing Activity-Based Cost Management:Moving from Analysis to Action. *Inst of Management Accountants*.

Kaplan, Robert S., & Haas, D. (2018). Defining, measuring, and improving value in spine care. *Seminars in Spine Surgery*, *30*(2), 80–83. https://doi.org/10.1053/j.semss.2017.11.001

Keel, G., Savage, C., Rafiq, M., & Mazzocato, P. (2017). Time-driven activity-based costing in health care: A systematic review of the literature. *Health Policy*, *121*(7), 755–763. https://doi.org/10.1016/j.healthpol.2017.04.013

Khataie, A. H., & Bulgak, A. A. (2013). A cost of quality decision support model for lean manufacturing: Activity-based costing application. *International Journal of Quality and Reliability Management*, *30*(7), 751–764. https://doi.org/10.1108/IJQRM-Jan-2011-0016

Kont, K. R. (2011). New cost accounting models in measuring of library employees' performance. *Library Management*, *33*(1–2), 50–65. https://doi.org/10.1108/01435121211203310

Kont, K. R. (2015a). How to optimize the cost and time of the acquisitions process? *Collection Building*, *34*(2), 41–50. https://doi.org/10.1108/CB-01-2015-0003

Kont, K. R. (2015b). What do acquisition activities really cost? A case study in Estonian university libraries. *Library Management*, *36*(6–7), 511–534. https://doi.org/10.1108/LM-12-2014-0137

Kostakis, H., Boskou, G., & Palisidis, G. (2011). Modelling activity-based costing in restaurants. *Journal of Modelling in Management*, *6*(3), 243–257. https://doi.org/10.1108/17465661111183676

Kuo, H. K., & Yang, C. (2014). An intellectual structure of activity-based costing: A co-citation analysis. *Electronic Library*, *32*(1), 31–46. https://doi.org/10.1108/EL-03-2012-0027

Laonapaporn, B., & Phanthunane, P. (2014). Activity based costing system of continuous ambulatory peritoneal dialysis under the Universal Coverage Scheme in Thailand. *BMC Public Health*, *14*(Suppl 1), P7. https://doi.org/10.1186/1471-2458-14-S1-P7

Lau, H., Nakandala, D., Samaranayake, P., & Shum, P. (2016). A hybrid multi-criteria decision model for supporting customerfocused profitability analysis. *Industrial Management and Data Systems*, *116*(6), 1105–1130. https://doi.org/10.1108/IMDS-10-2015-0410

Laviana, A. A., Ilg, A. M., Veruttipong, D., Tan, H. J., Burke, M. A., Niedzwiecki, D. R., … Saigal, C. S. (2016). Utilizing time-driven activity-based costing to understand the short- and long-term costs of treating localized, low-risk prostate cancer. *Cancer*, *122*(3), 447–455. https://doi.org/10.1002/cncr.29743

Lin, W. C. (2012). Financial performance and customer service: An examination using activity-based costing of 38 international airlines. *Journal of Air Transport Management*, *19*(1), 13–15. https://doi.org/10.1016/j.jairtraman.2011.12.002

Linassi, R., Alberton, A., & Marinho, S. V. (2016). Menu engineering and activity-based costing: An improved method of menu planning. *International Journal of Contemporary Hospitality Management*, *28*(7), 1417–1440. https://doi.org/10.1108/IJCHM-09-2014-0438

Liu, Y., & Gong, S. (2011). Production Management for Manufacturing Based on Activity-Based Costing. *Applied Mechanics and Materials*, *120*. https://doi.org/10.4028/www.scientific.net/AMM.120.432

Lu, T. Y., Wang, S. L., Wu, M. F., & Cheng, F. T. (2017). Competitive Price Strategy with Activity-Based Costing - Case Study of Bicycle Part Company. *Procedia CIRP*, *63*, 14–20. https://doi.org/10.1016/j.procir.2017.03.102

Maiga, A. S. (2014). Assessing self-selection and endogeneity issues in the relation between activity-based costing and performance. *Advances in Accounting*, *30*(2), 251–262. https://doi.org/10.1016/j.adiac.2014.09.009

Maiga, A. S., Nilsson, A., & Jacobs, F. A. (2014). Assessing the impact of budgetary participation on budgetary outcomes: the role of information technology for enhanced communication and activity-based costing. *Journal of Management Control*, *25*(1), 5–32. https://doi.org/10.1007/s00187-014-0191-9

Mandigo, M., O'Neill, K., Mistry, B., Mundy, B., Millien, C., Nazaire, Y., … Kaplan, R. (2015). A time-driven activity-based costing model to improve health-care resource use in Mirebalais, Haiti. *The Lancet*, *385*, S22. https://doi.org/10.1016/S0140-6736(15)60817-0

Marjanović, V., Gavrilović, J., & Stanić, N. (2011). Us American Versus German Activity-Based Costing. Effects on Business Decisions Management in Theautomotive Industry. *Economic Research-Ekonomska Istraživanja*, *24*(2), 99–111. https://doi.org/10.1080/1331677X.2011.11517459

Martino, M., Console, G., Russo, L., Meliado, A., Meliambro, N., Moscato, T., … Morabito, F. (2017). Autologous Stem Cell Transplantation in Patients With Multiple Myeloma: An Activity-based Costing Analysis, Comparing a Total Inpatient Model Versus an Early Discharge Model. *Clinical Lymphoma, Myeloma and Leukemia*, *17*(8), 506–512. https://doi.org/10.1016/j.clml.2017.05.018

Mortaji, S. T. H., Bagherpour, M., & Mazdeh, M. M. (2013). Fuzzy time-driven activity-based costing. *EMJ - Engineering Management Journal*, *25*(3), 63–73. https://doi.org/10.1080/10429247.2013.11431983

Muto, H., Tani, Y., Suzuki, S., Yokooka, Y., Abe, T., Sase, Y., … Ogasawara, K. (2011). Filmless versus film-based systems in radiographic examination costs: An activity-based costing method. *BMC Health Services Research*, *11*. https://doi.org/10.1186/1472-6963-11-246

Mwaikambo, E., Rajabifard, A., & Hagai, M. (2015). Modelling cost estimation for accessing spatial data using fuzzy logic and time-driven activity based costing in the context of an NSDI. *Journal of Spatial Science*, *60*(1), 137–151. https://doi.org/10.1080/14498596.2014.915768

Nassar, M., Al-Khadash, H. A., & Sangster, A. (2011). The diffusion of activity-based costing in Jordanian industrial companies. *Qualitative Research in Accounting and Management*, *8*(2), 180–200. https://doi.org/10.1108/11766091111137573

Nassar, M., Al-Khadash, H. A., Sangster, A., & Mah'D, O. (2013). Factors that catalyse, facilitate and motivate the decision to implement activity-based costing in Jordanian industrial companies. *Journal of Applied Accounting Research*, *14*(1), 18–36. https://doi.org/10.1108/09675421311282522

Noain, A., Garcia-Cardenas, V., Gastelurrutia, M. A., Malet-Larrea, A., Martinez-Martinez, F., Sabater-Hernandez, D., & Benrimoj, S. I. (2017). Cost analysis for the implementation of a medication review with follow-up service in Spain. *International Journal of Clinical Pharmacy*, *39*(4), 750–758. https://doi.org/10.1007/s11096-017-0454-2

Novak, D. D., Paulos, A., & Clair, G. S. (2011). Data-driven budget reductions: A case study. *Bottom Line*, *24*(1), 24–34. https://doi.org/10.1108/08880451111142015

Nowak, C., & Linder, C. (2016). Do you know how much your expatriate costs? An activity-based cost analysis of expatriation. *Journal of Global Mobility*, *4*(1), 88–107. https://doi.org/10.1108/JGM-10-2015-0043

Orji, I., & Wei, S. (2016). A detailed calculation model for costing of green manufacturing. *Industrial Management & Data Systems*, *116*(1), 65–86. https://doi.org/10.1108/IMDS-04-2015-0140

Palaiologk, A. S., Economides, A. A., Tjalsma, H. D., & Sesink, L. B. (2012). An activity-based costing model for long-term preservation and dissemination of digital research data: The case of DANS. *International Journal on Digital Libraries*, *12*(4), 195–214. https://doi.org/10.1007/s00799-012-0092-1

Phan, T. N., Baird, K., & Su, S. (2018). Environmental activity management: its use and impact on environmental performance. *Accounting, Auditing and Accountability Journal*, *31*(2), 651–673. https://doi.org/10.1108/AAAJ-08-2016-2686

Pongwasit, R., & Chompu-inwai, R. (2016). Analysis of Wooden Toy Manufacturing Costs Through the Application of a Time-Driven Activity-Based Costing System.

Memoirs of the Muroran Institute of Technology, *65*, 7–14.

Qingge, Z. (2012). A New Activity-Based Financial Cost Management Method. *Physics Procedia*, *33*, 1906–1912. https://doi.org/10.1016/j.phpro.2012.05.301

Quinn, M., Elafi, O., & Mulgrew, M. (2017). Reasons for not changing to activity-based costing: a survey of Irish firms. *PSU Research Review*, *1*(1), 63–70. https://doi.org/10.1108/PRR-12-2016-0017

Ridderstråle, M. (2017). Comparison between Individually and Group-Based Insulin Pump Initiation by Time-Driven Activity-Based Costing. *Journal of Diabetes Science and Technology*, *11*(4), 759–765. https://doi.org/10.1177/1932296816684858

Ríos-Manríquez, M., Muñoz Colomina, C. I., & Rodríguez-Vilariño Pastor, M. L. (2014). Is the activity based costing system a viable instrument for small and medium enterprises? The case of Mexico. *Estudios Gerenciales*, *30*(132), 220–232. https://doi.org/10.1016/j.estger.2014.02.014

Salem-Mhamdia, A. B. H., & Ghadhab, B. B. (2012). Value management and activity based costing model in the Tunisian restaurant. *International Journal of Contemporary Hospitality Management*, *24*(2), 269–288. https://doi.org/10.1108/09596111211206178

Sarokolaei, M. A., Bahreini, M., & Bezenjani, F. P. (2013). Fuzzy Performance Focused Activity based Costing (PFABC). *Procedia - Social and Behavioral Sciences*, *75*, 346–352. https://doi.org/10.1016/j.sbspro.2013.04.039

Schoute, M. (2011). The relationship between product diversity, usage of advanced manufacturing technologies and activity-based costing adoption. *British Accounting Review*, *43*(2), 120–134. https://doi.org/10.1016/j.bar.2011.02.002

Schulze, M., Seuring, S., & Ewering, C. (2012). Applying activity-based costing in a supply chain environment. *International Journal of Production Economics*, *135*(2), 716–725. https://doi.org/10.1016/j.ijpe.2011.10.005

Scott, T. M., Tucker, K. L., Bhadelia, A., Benjamin, B., Patz, S., Bhadelia, R., … Folstein, M. F. (2004). Homocysteine and B vitamins relate to brain volume and white-matter changes in geriatric patients with psychiatric disorders. *American Journal of Geriatric Psychiatry*, *12*(6), 631–638. https://doi.org/10.1080/00207543.2010.537389

Sembiring, M. T., Wahyuni, D., Sinaga, T. S., & Silaban, A. (2018). Study of activity based costing implementation for palm oil production using value-Added and non-value-Added activity consideration in PT XYZ palm oil mill. *IOP Conference Series: Materials Science and Engineering*, *309*(1). https://doi.org/10.1088/1757-899X/309/1/012059

Shigaev, A. (2015). Accounting Entries for Activity-Based Costing System: The Case of a Distribution Company. *Procedia Economics and Finance*, *24*(July), 625–633. https://doi.org/10.1016/S2212-5671(15)00652-8

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. *Journal of Academic Librarianship*, *42*(3), 232–246. https://doi.org/10.1016/j.acalib.2016.01.005

Siguenza-Guzman, L., Van den Abbeele, A., & Cattrysse, D. (2014). Improving Library Management by Using Cost Analysis Tools: A Case Study for Cataloguing Processes. *LIBER Quarterly*, *23*(3), 160. https://doi.org/10.18352/lq.8558

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

Sorros, J., Karagiorgos, A., & Mpelesis, N. (2017). Adoption of Activity-Based Costing: A Survey of the Education Sector of Greece. *International Advances in Economic Research*, *23*(3), 309–320. https://doi.org/10.1007/s11294-017-9640-1

Stefano, N. M., Lisbôa, M. da G. P., & Casarotto Filho, N. (2012). Activity-Based Costing: Estado Da Arte Proposta Pelo Pesquisador E Revisão Bibliométrica Da Literatura. *Iberoamerican Journal of Project Management*, *3*(1), 1–11.

Stout, D. E., & Propri, J. M. (2011). Implementing Time-Driven Activity-Based Costing at a Medium-Sized Electronics Company. *Management Accounting Quarterly*, *12*(3), 1–11.

Suthummanon, S., Ratanamanee, W., Boonyanuwat, N., & Saritprit, P. (2011). Applying activity-based costing (ABC) to a parawood furniture factory. *Engineering Economist*, *56*(1), 80–93. https://doi.org/10.1080/0013791X.2010.549936

Tibesku, C. O., Hofer, P., Portegies, W., Ruys, C. J. M., & Fennema, P. (2013). Benefits of using customized instrumentation in total knee arthroplasty: Results from an activity-based costing model. *Archives of Orthopaedic and Trauma Surgery*, *133*(3), 405–411. https://doi.org/10.1007/s00402-012-1667-4

Tsai, W. H., Chang, J. C., Hsieh, C. L., Tsaur, T. S., & Wang, C. W. (2016). Sustainability concept in decision-making: Carbon tax consideration for joint product mix decision. *Sustainability (Switzerland)*, *8*(12), 1–22. https://doi.org/10.3390/su8121232

Tsai, W. H., Chen, H. C., Leu, J. Der, Chang, Y. C., & Lin, T. W. (2013). A product-mix decision model using green manufacturing technologies under activity-based costing. *Journal of Cleaner Production*, *57*, 178–187. https://doi.org/10.1016/j.jclepro.2013.04.011

Tsai, W. H., Lee, K. C., Liu, J. Y., Lin, H. L., Chou, Y. W., & Lin, S. J. (2012). A mixed activity-based costing decision model for green airline fleet planning under the constraints of the European Union Emissions Trading Scheme. *Energy*, *39*(1), 218–226. https://doi.org/10.1016/j.energy.2012.01.027

Tsai, W. H., Shen, Y. S., Lee, P. L., Chen, H. C., Kuo, L., & Huang, C. C. (2012). Integrating information about the cost of carbon through activity-based costing. *Journal of Cleaner Production*, *36*, 102–111. https://doi.org/10.1016/j.jclepro.2012.02.024

Tsai, W. H., Tsaur, T. S., Chou, Y. W., Liu, J. Y., Hsu, J. L., & Hsieh, C. L. (2015). Integrating the activity-based costing system and life-cycle assessment into green decision-making. *International Journal of Production Research*, *53*(2), 451–465. https://doi.org/10.1080/00207543.2014.951089

Tsai, W. H., Yang, C. H., Chang, J. C., & Lee, H. L. (2014). An Activity-Based Costing decision model for life cycle assessment in green building projects. *European Journal of Operational Research*, *238*(2), 607–619. https://doi.org/10.1016/j.ejor.2014.03.024

Ussahawanitchakit, P. (2017). Activity-Based Costing of Canned and Processed Foods Businesses in Thailand : Effects on Organizational Development , 215–225. https://doi.org/10.3846/btp.2017.023

van der Linden, Y. T. K., Govaert, J. A., Fiocco, M., van Dijk, W. A., Lips, D. J., & Prins, H. A. (2017). Single center cost analysis of single-port and conventional laparoscopic surgical treatment in colorectal malignant diseases. *International Journal of Colorectal Disease*, *32*(2), 233–239. https://doi.org/10.1007/s00384-016-2692-5

Van Dyk, J., Zubizarreta, E., & Lievens, Y. (2017). Cost evaluation to optimise radiation therapy implementation in different income settings: A time-driven activity-based analysis. *Radiotherapy and Oncology*, *125*(2), 178–185. https://doi.org/10.1016/j.radonc.2017.08.021

Vij, M. (2012). A survey of factors influencing cost structures in the Indian hotel sector. *Worldwide Hospitality and Tourism Themes*, *4*(5), 449–462. https://doi.org/10.1108/17554211211277888

Villarmois, O. D. La, & Levant, Y. (2011). From adoption to use of a management control tool: Case study evidence of a costing method. *Journal of Applied Accounting Research*, *12*(3), 234–259. https://doi.org/10.1108/09675421111187683

Waters, P. M. (2015). Value in pediatric orthopaedic surgery health care: The role of time-driven activity-based cost accounting (TDABC) and standardized clinical assessment and management plans (SCAMPs). *Journal of Pediatric Orthopaedics*, *35*(5), S45–S47. https://doi.org/10.1097/BPO.0000000000000547

Wouters, M., & Stecher, J. (2017). Development of real-time product cost measurement: A case study in a medium-sized manufacturing company. *International Journal of Production Economics*, *183*(November 2016), 235–244. https://doi.org/10.1016/j.ijpe.2016.10.018

Wu, S. I., & Chen, J. H. (2012). The performance evaluation and comparison based on enterprises passed or not passed with ISO accreditation: An appliance of BSC and ABC methods. *International Journal of Quality and Reliability Management*, *29*(3), 295–319. https://doi.org/10.1108/02656711211216153

Yang, C. H. (2018). An optimization portfolio decision model of life cycle activity-based costing with carbon footprint constraints for hybrid green power strategies. *Computers and Operations Research*, *96*, 256–271. https://doi.org/10.1016/j.cor.2018.03.003

Yang, C. H., Lee, K. C., & Chen, H. C. (2016). Incorporating carbon footprint with activity-based costing constraints into sustainable public transport infrastructure project decisions. *Journal of Cleaner Production*, *133*, 1154–1166. https://doi.org/10.1016/j.jclepro.2016.06.014

Yu, Y. R., Abbas, P. I., Smith, C. M., Carberry, K. E., Ren, H., Patel, B., … Lopez, M. E. (2016). Time-driven activity-based costing to identify opportunities for cost reduction in pediatric appendectomy. *Journal of Pediatric Surgery*, *51*(12), 1962–1966. https://doi.org/10.1016/j.jpedsurg.2016.09.019

Yu, Y. R., Abbas, P. I., Smith, C. M., Carberry, K. E., Ren, H., Patel, B., … Lopez, M. E. (2017). Time-driven activity-based costing: A dynamic value assessment model in pediatric appendicitis. *Journal of Pediatric Surgery*, *52*(6), 1045–1049. https://doi.org/10.1016/j.jpedsurg.2017.03.032

Yun, B. J., Prabhakar, A. M., Warsh, J., Kaplan, R., Brennan, J., Dempsey, K. E., & Raja, A. S. (2016). Time-Driven Activity-Based Costing in Emergency Medicine. *Annals of Emergency Medicine*, *67*(6), 765–772. https://doi.org/10.1016/j.annemergmed.2015.08.004

Zhang, X., Lee, C. K. M., & Chen, S. (2012). Supplier evaluation and selection: A hybrid model based on DEAHP and ABC. *International Journal of Production Research*, *50*(7), 1877–1889. https://doi.org/10.1080/00207543.2011.560908

Zheng, C. W., & Abu, M. Y. (2019). Application of Activity Based Costing for Palm Oil Plantation, *02*, 1–14.

Zhuang, Z. Y., & Chang, S. C. (2017). Deciding product mix based on time-driven activity-based costing by mixed integer programming. *Journal of Intelligent Manufacturing*, *28*(4), 959–974. https://doi.org/10.1007/s10845-014-1032-2

APPENDIX A LIST OF PUBLICATIONS

Zamrud, N.F., Nik Mohd Kamil, N.N., Abu, M.Y., and Safeiee, F.L.M. (2019). The Impact of Capacity Cost Rate and Time Equation of Time-Driven Activity-Based Costing (TDABC) on Electrics and Electronics Industry. Proceedings of the International Manufacturing Engineering Conference & The Asia Pacific Conference on Manufacturing System. 81-87.

Zamrud, N.F., Nik Mohd Kamil, N.N., Abu, M.Y., and Safeiee, F.L.M. (2019). A Comparative Study of Product Costing by Using Activity-Based Costing and Time-Driven Activity-Based Costing (TDABC) Method. Proceedings of the International Manufacturing Engineering Conference & The Asia Pacific Conference on Manufacturing System. 171-178.

Zamrud, N.F., Nik Mohd Kamil, N.N., Abu, M.Y., and Safeiee, F.L.M., and Oktaviandri, M. (2019). A Review on the Application of Activity-Based Costing and Time-Driven Activity-Based Costing in Manufacturing Industry. 4th International Conference on Engineering Technology. (Presented)

Zamrud, N.F., Abu, M.Y., Nik Mohd Kamil, N.N., and Safeiee, F.L.M., and Oktaviandri, M. (2019). Application of Activity-Based Costing in Production Environment. 4th International Conference on Engineering Technology. (Presented)

Nik Mohd Kamil, N.N., Abu, M.Y., **Zamrud, N.F.**, and Safeiee, F.L.M. (2019). Analysis of Magnetic Component Manufacturing Cost Through the Application of Time-Driven Activity Based Costing. Proceedings of the International Manufacturing Engineering Conference & The Asia Pacific Conference on Manufacturing System. 74-80.

Nik Mohd Kamil, N.N., Abu, M.Y., **Zamrud, N.F.**, and Safeiee, F.L.M. (2019). Proposing of Mahalanobis-Taguchi System and Time-Driven Activity-Based Costing on Magnetic Component of Electrical & Electronic Industry. Proceedings of the International Manufacturing Engineering Conference & The Asia Pacific Conference on Manufacturing System. 108-114.

Safeiee, F.L.M., **Zamrud, N.F.**, Nik Mohd Kamil, N.N., and Abu, M.Y. (2019). The Application of Time-Driven Activity-Based Costing (TDABC) on Inductors in Electrics and Electronics Industry. Proceedings of the International Manufacturing Engineering Conference & The Asia Pacific Conference on Manufacturing System. 88-95.

Safeiee, F.L.M., **Zamrud, N.F**., Nik Mohd Kamil, N.N., and Abu, M.Y. (2019). Diagnosis and Costing Optimization on Inductors in Electrics and Electronics Industry. Proceedings of the International Manufacturing Engineering Conference & The Asia Pacific Conference on Manufacturing System. 121-127.

Nik Mohd Kamil, N.N., Abu, M.Y., **Zamrud, N.F**., and Safeiee, F.L.M., and Oktaviandri, M. (2019). A Review on the Integration of Mahalanobis-Taguchi System and Time-Driven Activity-Based Costing on Production Environment. 4th International Conference on Engineering Technology. (Presented)

Nik Mohd Kamil, N.N., Abu, M.Y., **Zamrud, N.F**., and Safeiee, F.L.M., and Oktaviandri, M. (2019). Application of Mahalanobis-Taguchi System on Electrical and Electronic Industry. 4th International Conference on Engineering Technology. (Presented)

Safeiee, F.L.M., Abu, M.Y., **Zamrud, N.F**., and Nik Mohd Kamil, N.N. (2019). Exploring Beneficial of Mahalanobis-Taguchi Method on Production Environment. 4th International Conference on Engineering Technology. (Presented)

Safeiee, F.L.M., Abu, M.Y., **Zamrud, N.F**., and Nik Mohd Kamil, N.N. (2019).Development of a New Costing Structure in Production Environment using Activity-Based Costing. 4th International Conference on Engineering Technology. (Presented)

APPENDIX B ABC AND TDABC JOURNALS SUMMARY

No.	Authors	Application	Method	Issue	Findings
1.	(Yang, 2018)	Green power strategies	ABC	Different information provided by TCS such as cost, resources and activity categories.	-ABC allowed identification of process resources and activity traces.
2.	(Fito, Llobet, & Cuguero, 2018)	Literature review	ABC	ABC halted due to conceptual and shortcomings in terms of definition and difficulties in implementation process.	-ABC had not able to overcome conceptual and operational shortcomings.
3.	(Sembiring et al., 2018)	Palm oil production	ABC	Company processing time is not in accordance with actual processing time at work station.	- ABC performed activity improvements. - ABC calculated cost of goods manufactured and result compared with traditional method.
4.	(Husby, Tolstrup, Lose, & Klarskov, 2018)	Vaginal hysterectomy with uterosacral ligament suspension	ABC	With limited healthcare resources, it is relevant to apply procedures that offer good quality at reasonable costs.	- ABC revealed total cost of the operations.
5.	(Phan, Baird, & Su, 2018)	Environmental activity management	EABC	Inadequate of TCS in providing accurate environmental information.	- EABC enabled more accurate allocation of environmental cost to cost objects. -EABC traced environmental costs of activities to products and services.
6.	(Allain & Laurin, 2018)	Insurance company	ABC	Lack of knowledge of difficulties arising during ABC implementation.	-ABC illustrated difficulties with the implementation of the system itself.
7.	(Martino et al., 2017)	Autologous Stem Cell Transplantation	ABC	The need to evaluate the impact of new therapies on health care costs.	- ABC observed cost savings in health care.
8.	(Greasley & Smith, 2017)	Police communication center	ABC	The need to cut expenditure whilst maintaining service level.	- ABC identified how cost is incurred. - ABC enabled targeted approach to reduce cost.
9.	(Almeida & Cunha, 2017)	Coffee production manufacturing company	ABC	Mere knowledge of particular product cost	- ABC provided relevant and useful information for decision-making process. - ABC revealed specific allocation to each activity of the resources consumed.
10.	(Hofmann & Bosshard, 2017)	Supply chain management (SCM)	ABC	Lack of knowledge of intersecting literature of SCM and ABC.	- ABC demonstrated effectiveness of the management tool. - ABC revealed expected improvement in supply chain competitiveness.
11.	(Quinn et al., 2017)	Irish firms	ABC	The need to examine how IT developments impacted ABC adoption.	- It seemed respondent firms are satisfied with traditional costing methods.
12.	(Lu et al., 2017)	Bicycle part company	ABC	Complicated cost structure affecting price strategy.	- ABC provided accurate information cost with cost drivers. - ABC provided relationship s between resources consumption and cost during manufacturing process.
13.	(Sorros et al., 2017)	Eduacation sector of Greece	ABC	Lack of knowledge of ABC adoption in education sector.	- ABC enhanced pricing and wage policies, thus improved quality services. - ABC minimized cost and reduced tuition.

14.	(Linassi, Alberton, & Marinho, 2016)	Menu planning	ABC	Traditional Menu Engineering approach only uses food costs to determine the contribution margin (CM).	- ABC methods are applicable to an oriental-style restaurant. -ABC with ME identified increased food-costs and lower CM.
15.	(Ussahawanitchakit, 2017)	Canned and processed food business in Thailand	ABC	The need to determine and utilize valuable organizational strategies and implement best business practices.	- ABC is an innovative management accounting method. -ABC gained sustainable competitive advantage and superior performance.
16.	(Chouhan et al., 2017)	Inventory evaluation	ABC	Relevancy of traditional methods for decision-making process.	- ABC improved management accounting systems. - ABC controlled indirect inventory cost. - ABC improved the operation decision-making. - ABC specifically disclosed finished goods and all the other items of cost in their cost accounting records. - ABC helped manager understand inventory cost and eliminated waste. - ABC provided road map to remove complexity in valuating inventory. - ABC can be used as separate management decision support system where activity-based products cost are determined.
17.	(Feng & Ho, 2016)	Accounting management	ABC	Investing ABC is analogous to having option right in financial call option.	ROA model to decide whether to adopt or decline ABC method in company.
18.	(Cassettari et al., 2016)	IVF cycle cost estimation	ABC	Deterministic regime is inadequate to implement accurate cost estimate.	- ABC divided direct and indirect costs, provided allocation generated activities. -Through cost drivers, ABC provided attribution to the treatment.
19.	(Yang et al., 2016)	Public transport infrastructure	ABC	The need to have effective control of information related to infrastructure cost.	- ABC calculated and allocated direct and indirect cost.
20.	(Nowak & Linder, 2016)	Analysis of expatriation	ABC		-ABC allowed to conceptualize expatriation as a process. - ABC combined different types of costs over time. - ABC has advantage over static approaches.
21.	(Lau, Nakandala, Samaranayake, & Shum, 2016)	Airline management	ABC&M	The company might overlook critical building blocks, resulting unsatisfactory profitability.	- ABC formulated process improvement and cost reduction programs. - ABC measured accurate and relevant product, process, service and activity costs. -ABC calculated customer profitability.
22.	(Orji & Wei, 2016)	Green manufacturing	ABC	To ascertain the costs of green manufacturing.	- ABC calculated total life cycle cost of product.
23.	(Shigaev, 2015)	Accounting system	ABC	In order for the activity-based accounting to be implemented in a Russian company, it is necessary to open one group of accounts	- ABC aligns fees with services and assumes the company earns a target margin on its basic product or service.

				for usual responsibility and resource accounting purposes and another group of accounts to record costs by activities.	
24.	(Adane et al., 2015)	Clinical chemistry and hematology services	ABC	The health care cost aggravates the frequently low priority and less attention given in financing laboratory services.	-ABC used for correct cost estimation, revenue estimation of profitability analysis, efficient resource allocation, and improved quality service provision.
25.	(Haroun, 2015)	Service industry	ABC	The service providers have a problem of estimating the right fair costs.	- ABC provided more accurate cost estimates rather than the TOC. - ABC distributed the overhead costs in proportion (fairly) to the actual activities performed in a specific job.
26.	(Tsai et al., 2015)	Electrical and electric industry	ABC	Lack of justification for manufacturing systems, selecting the best production project in terms of sustainability.	-ABC estimated total environmental cost. - ABC traced sustainable overhead costs to cost objects, and provided better overview of cost.
27.	(Kont, 2015b)	Print format books	ABC	The need to justify costs to parent organizations has become particularly important.	-ABC is the best tools for understanding acquisitions cost behavior and for refining a cost system for university libraries.
28.	(Cannavacciuolo et al., 2015)	Orthopedic division	ABC	Lack of knowledge of designing and implementation of cost accounting systems in healthcare organizations.	- ABC produced significant information about consumed resources and the costs of the activities.
29.	(Tsai, Yang, Chang, & Lee, 2014)	Green building industry	ABC	The need to have accurate building cost information and to a reduction in the environmental impact of the projects.	-ABC helped to more accurately understand to allocate resources and funding. - ABC provided pre-construction decision-making tool.
30.	(Ibrahim, Nur, Hassan, Am, & Aljunid, 2014)	Radiology Department of health care	ABC	Lack of knowledge of the actual cost of each procedure in this particular department.	- ABC determined an accurate and precise cost per radiological procedure.
31.	(Ríos-Manríquez, Muñoz Colomina, & Rodríguez-Vilariño Pastor, 2014)	Small and medium-sized firms (SME)	ABC	The need to develop strategies enabling them to control their costs.	- ABC is recognized for its compatibility and usefulness.
32.	(Alsmadi et al., 2014)	Lean company	ABC TOC	Lack of appropriate cost accounting systems.	- ABC should viewed as mutual exclusive approaches but can be used in a complementary manner to determine the right product-mix. - ABC offered a decided competitive advantage for Lean companies. - ABC provided integrated approach for strategic decision making, including controlling costs and developing more profitable business strategies.
33.	(Maiga, Nilsson, & Jacobs, 2014)	Budgetary participation	ABC	Inconsistent relationship between budgetary participation and managerial performance.	ABC significantly moderated the relationship between budgetary participation and managerial performance.
34.	(Maiga, 2014)	Manufacturing plant	ABC	Inconclusive relationship between ABC adoption and manufacturing plant.	- Provided insight into relationship between ABC adoption and plant performance.

					- ABC adoption and plant profitability eased justification of investment in ABC and eased to developed related management control procedures.
35.	(Kuo & Yang, 2014)	Co-citation analysis of Google Scholar	ABC	Further knowledge into the core ideas underpinning the ABC discipline.	-First intellectual structure of ABC discipline through document co-citation analysis and multivariate statistical analysis. - Broaden a researcher's ABC knowledge to more effectively and efficiently conduct their works.
36.	(Intakhan, 2014)	ISO 9000 certified companies	ABC	Lack of knowledge of the ABC implementation success in the context of ISO 9000 companies.	- ABC implementation success of ISO 9000 certified companies in Thailand consists of upper-management support, ABC system training, non-accounting ownership, links to quality initiative, adequate resources, and links to performance evaluation.
37.	(Laonapaporn & Phanthunane, 2014)	Continuous Ambulatory Peritoneal Dialysis (CAPD) of health care.	ABC	No information on the real cost based on patients' background.	-ABC computed cost of CAPD per patient.
38.	(Esmalifalak et al., 2015)	Health care	TABC FABC MCABC	Precise input data are rarely if ever available, all output values are subject to uncertainty.	- Unit cost of services was calculated. - FABC and MCABC led to significantly different cost estimates from TABC.
39.	(Khataie & Bulgak, 2013)	Lean manufacturing	ABC	The traditional cost accounting (TCA) is a transaction-oriented approach, but a LM process requires activity-oriented cost information.	- ABC controlled the COQ via using a novel SD modelling methodology.
40.	(Carli & Canavari, 2013)	Agribusiness management	ABC	Undeveloped cost analyses in actual Farm Management Information Systems (FMIS).	- ABC provided cost management in FMIS. - ABC enabled detailed view of costs and allocated general costs.
41.	(Cugini, Michelon, & Pilonato, 2013)	Rail transport company	ABC	In search of the cost accounting system that companies in the railway transport industry should adopt in order to support the new dynamics of the liberalization process.	- ABC facilitated the operational connection between the company's resources and their consumption during the provision of transport services.
42.	(Sarokolaei, Bahreini, & Bezenjani, 2013)	Product price	FPFABC	PFABC face with the phenomenon of ambiguity and uncertainty in estimating of standards as system input.	- The comparison ABC and FABC enabled us to gain excessive and valuable information about effective behavior of the price when inaccurate and non-absolute data are present. - FABM used as management's decision-making tools in other areas such as customers' profitability.
43.	(Nassar et al., 2013))	Jordanian industrial companies	ABC	In spite of facilitating and motivating factors in the external environment, the implementation of ABC in companies is disappointing.	- ABC implementation was facilitated by the provision of adequate training and increasing proportion of overhead costs, and an increasing number of product variants.

					- ABC barrier was high cost of implementation.
44.	(Gregorio & Soares, 2013)	Civil construction projects	ABC	The major drawback of all costing methods is that they induce subjective and arbitrary elements when dealing with the apportionment of indirect costs.	- Level of bureaucracy of the MIXBC is inferior to ABC.
45.	(Tibesku, Hofer, Portegies, Ruys, & Fennema, 2013)	Total knee arthroplasty	ABC	There are continued pressures in all advanced economies to contain the growth in healthcare expenditure.	- ABC increased efficiency of operating room usage and utilization of surgical trays. - ABC estimated potential revenues by efficient utilization of time saved.
46.	(Stefano, Lisbôa, & Casarotto Filho, 2012)	ABC in service review	ABC	Lack of information to improve the efficiency of the management.	- ABC required detailed study of organizations. - ABC applied to services such as hospitals, hotels, libraries, police services, job shop, postal services, transportation company, financial and logistic services.
47.	(Tsai et al., 2013)	Product mix using Green Manufacturing Technologies (GMTs)	ABC TOC MIP	Facility operators need accurate information from management accounting account to make profitable choices regarding environmental spending.	- ABC improved the efficiency and effect of the product-mix decision model. - ABC solved traditional drawbacks and problems. - The optimal product-mix from ABC combined with TOC was accurate than traditional accounting.
48.	(Scott et al., 2004)	Green Manufacturing Systems (GMSs)	ABC	Lack of appropriate justification of green manufacturing systems.	- ABC enabled quantifying and incorporating intangible benefits costs into investment justification procedure. - ABC and economic value analysis were a sound basis for alternatives of manufacturing system. - ABC system determined the performance of GMS.
49.	(Salem-Mhamdia & Ghadhab, 2012)	Tunisian restaurant	ABC	Restaurant managers find it difficult to simultaneously improve customer satisfaction and profit.	- ABC showed that 11 menu items profitable. - ABC determined the costs and analyzed customer satisfaction. -ABC calculated the earnings generated by different proposed products and provided product value for the menu items by calculating operating profit margin and customer satisfaction with the different products. - ABC/VM have significant benefits for restaurant management and enhanced the quality of the decision-making process.
50.	(Wu & Chen, 2012)	Manufacturing and service industry	ABC	Lack of knowledge of detailed performance effects of ISO accreditation.	- ABC measures used to compare performance difference through objective financial data. - ABC provided real financial information by the analysis that confirms that the pass of ISO accreditation by a manufacturing enterprise

					can effectively improve profitability.
51.	(Zhang, Lee, & Chen, 2012)	Electronics manufacturing firm	ABC	The existing investigations are mostly focused on either supplier performance in terms of efficiency or on the total cost of sourcing.	- ABC employed to evaluate the performance of Supplier A/B/C in term of costs. - ABC put more emphasis on cost-related factors, such as purchasing price, production disruption cost and set up cost, and ignores other factors.
52.	(Tsai, Shen, et al., 2012)	Paper industry	ABC	Inaccurate environmental costs by organization due to the use of TCA.	- ABC produced accurate estimations of the environmental costs of final products. -ABC represented environmental cost structure.
53.	(Lin, 2012)	International airlines services	ABC	Potential savings to be made from improved operational processes and elimination of other inefficiency.	- ABC incorporated a variety of potentially important factors that influence airline performance.
54.	(Dessureault & Benito, 2012)	Mining industries	ABC	The evolution of information technology in most contemporary industries has resulted in the increase in both volume and complexity of transactional data.	- ABC allowed redistribution of unallocated O&M costs to individual machine. - ABC traced cost drivers of O&M expenses.
55.	(Burnett, Wilson, Pfeffer, Lowry, & Bipac, 2012)	Pathology	ABC	Understanding of cost structure and resource consumption can be achieved, providing laboratory managers with the opportunity to perform marginal cost analysis and simulations to determine the best methods of undertaking specific analytical procedures.	- ABC overcame many problems of previous benchmarking studies based on total costs.
56.	(Schulze, Seuring, & Ewering, 2012)	Supply chain management	ABC	Traditional intra-firm cost accounting tool are inappropriate in the context of supply chain management, as there are not standards for the definition and composition of costs.	- ABC supported related supply chain decision. -ABC improved overall supply chain performance.
57.	(Cannavacciuolo, Iandoli, Ponsiglione, & Zollo, 2012)	Manufacturing production process.	ABC	Lack of methods to evaluate costs and benefits associated with the acquisition and use of new individual competencies.	- ABC made managers more aware of the nature of competencies and of their role in the activation of critical processes. - ABC allowed company managers to spot critical competencies, characterized by a high costs and high impact on value creation, on a factual basis.
58.	(Palaiologk, Economides, Tjalsma, & Sesink, 2012)	Digital research data	ABC	Insufficient of information level provided to the management by annual cost figures.	- ABC supplemented the information available from traditional accounting method.
59.	(Vij, 2012)	Hotel management	ABC	Lack of knowledge on current trends regarding the cost structures in hospitality industry.	- ABC was accepted as one of the most important innovations in the field of accounting. - ABC was needed to modernize the cost accounting systems. - ABC improved customer profitability analysis,

					budgeting process and overall cost reduction.
60.	(Qingge, 2012)	Financial cost management	ABC	Need of more advanced management and the enhancement of their own competitive abilities.	- ABC was suitable to use for marketing section and after-sale service section. - ABC used to manage manufacturing overhead, resource consuming before and after production of every section.
61.	(Tsai, Lee, et al., 2012)	Green airline fleet planning	ABC	Lack of understanding of the importance of the financial situation of airlines, analyzing cost structure and choosing lowest cost mode of operation.	- ABC analysis for the feasibility of research in aviation industry was strengthening. - ABC acted as the cost-measure basis.
62.	(Suthummanon et al., 2011)	Parawood furniture factory	ABC	Need for a more accurate costing system for estimating product costs in this industry.	- ABC computed different costs compared to TCS. - ACB provided management with reliable cost information.
63.	(Marjanović, Gavrilović, & Stanić, 2011)	Business decisions management in automotive industry	ABC	The need to identify and realize potential cost reduction opportunities.	- ABC improved cost calculation and optimize overall creation of value.
64.	(Huang & Li, 2011)	Environmental costs	ABC	How to improve economic benefits without the expense of the environmental has become a common concern.	- ABC provided more detailed information on the environmental costs accurately.
65.	(Schoute, 2011)	Advanced Manufacturing Technologies (AMT)	ABC	Inconclusive results of empirical research on the relationship between product diversity and ABC adoption.	- Relationship between product diversity and ABC use (not adoption) is negatively moderated by usage of AMT. - ABC use appeared stronger than ABC adoption on the associations of product diversity and usage of AMT.
66.	(Nassar, Al-Khadash, & Sangster, 2011)	Jordanian industrial companies	ABC	Studies on the spread of ABC among companies enrich our understanding of the motivation for change.	- ABC implementation in the Jordanian industrial sector followed the classical S-shape, but not a sufficient condition for companies to implement ABC.
67.	(Kont, 2011)	Library employees' performance	ABC	No knowledge on the cost accounting models adapted by university libraries from the perspective of employees.	- ABC can only be implemented in collaboration with the accounting department of the university if the library itself does not have one.
68.	(Kostakis, Boskou, & Palisidis, 2011)	Restaurant industry	ABC	Difficult to translate theory into action, mainly due to difficulties relating to data collection, identification of activities and lack of resource.	- ABC promoted time saving as it reduced interviews and survey practices for cost driver estimation. - ABC reduced probability inaccurate estimation of cost drivers.
69.	(Villarmois & Levant, 2011)	Management accounting	ABC	Incomplete and diverging conclusion of utilization of ABC.	- UVA limited use as a management tool compared to ABC.
70.	(Muto et al., 2011)	Radiographic examination cost	ABC	Undetermined radiographic examination cost and cost structure	- ABC calculated cost of radiographic examinations. - ABC enhanced greater value services to patients.
71.	(Novak, Paulos, & Clair, 2011)	Library services	ABC	Many sectors of the economy are currently striving to cut budgets and improve efficiency in response to the ongoing and deepening recession.	- ABC led to constructive organizational decision making and outcomes.

72.	(Fang & Ng, 2011)	Construction logistics cost analysis	ABC	Necessity to identify which are the most cost-sensitive elements within a logistics system such that appropriate actions can be taken to control if not to reduce the cost.	- ABC traced back resources consumed to the consuming activity and subsequently to a particular cost element. - ABC identified a logistics option which would result in the lowest logistics cost without affecting the construction schedule.

TDABC journals summary

No.	Authors	Application	Method	Issue	Findings
1.	(Erhun et al., 2015)	Multivessel coronary artery bypass grafting	TDABC	The need to compare and explain the difference in production cost in different places.	- TDABC allows granular comparison of the cost
2.	(Haas & Kaplan, 2017)	Medical	TDABC	Lack of accurate costs of resources used.	- TDABC provides both accurate and estimates of care cycle costs, as well as greater transparency into the drivers of those costs.
3.	(Beriwal & Chino, 2018)	Advanced cervical cancer in oncology	TDABC	Lack of accurate cost information of brachytherapy.	- TDABC able to calculate true cost of care for individual patients. - TDABC identify processes whose efficiency can be improved without affecting the outcome.
4.	(Barros & Da Costa Ferreira, 2017)	Manufacturing company	TDABC	Suitability and complexity of TDABC in manufacturing company.	- TDABC is suitable for manufacturing company. - Able to deal with variability of industrial process. - TDABC is more complex for manufacturing compared to the model presented in literature.
5.	(Yu et al., 2017)	Pediatric appendicitis of healthcare	TDABC	Lack of knowledge to quantify quality and cost.	- TDABC dynamically model changes in healthcare delivery.
6.	(Andreasen et al., 2017)	Hip and Knee Arthroplasty	TDABC	The need to have baseline detailed economical calculations of the process.	- TDABC provide detailed baseline calculations for comparison and further optimization of cost-benefit effectiveness.
7.	(Da Silva Medeiros et al., 2017)	Lean manufacturing industries	TDABC ABC VSC	Need for improvements in the traditional accounting system. Need to evaluate degree of integration of TDABC, ABC, VSC with Lean Manufacturing model.	- TDABC, ABC and VSC are not actually integrated to the production analysis process.
8.	(Keel et al., 2017)	Value-based health care	TDABC	Lack of knowledge of TDABC in health care and its application.	- TDABC is applicable in health care and help to efficiently cost processes and overcome challenge associated with current cost-accounting methods. - TDABC able to address complexity in health care. - TDABD should be gradually incorporated into functional systems.
9.	(Gonzalez, Nachtmann, & Pohl, 2017)	Health care provider	TDABC	To have a clear understanding of supply chain process cost and reduction opportunities.	- TDABC allows for activities to have multiple time drivers and better capture complexity. - TDABC eliminated some challenges that traditional ABC poses. - TDABC is effective and manageable to implement health care study.
10.	(van der Linden et al., 2017)	Laparoscopic surgical treatment in medical health	TDABC	Limited knowledge of cost effectiveness and learning curve of single-port laparoscopy (SPL) technique.	- TDABC reveals the technique cost effectiveness.

11.	(Helmers et al., 2017)	Gastrointestinal endoscopic procedures	TDABC	Lack of knowledge of true cost of endoscopic procedures.	- TDABC allows total cost measurement approach that the existing cost measurements are incapable of.
12.	(Goense et al., 2017)	Esophagectomy for cancer	TDABC	Need to optimally allocate resource for quality improvement	- TDABC reveals the cost reduction and quality improvement.
13.	(Bauer-Nilsen et al., 2018)	External beam radiation therapy and brachytherapy for locally advanced cervical cancer	TDABC	Challenge of understanding the actual cost	-TDABC used to calculate total cost of definitive radiation therapy.
14.	(Anzai et al., 2017)	Academic Radiology Department	TDABC	The lack of understanding of real cost of healthcare delivery services.	- TDABC provides valuable insights into process variability and resource utilization.
15.	(Wouters & Stecher, 2017)	Medium-sized manufacturing company	TDABC	Need to understanding data availability and updating in designing product costing system. To assess the profitability of products on a more comprehensive basis than contribution margins of products.	- Understanding limitations of TDABC - TDABC provides real time costing method for every business order. Limitation - In this study, the time equation is not applicable. - TDABC as a data discovery process is time consuming. Future research - Address how real-time aspect could be extended to other activities (product development or quality management) - Investigate significant of making real time adjustment of cost for the first-stage allocation.
16.	(Hamid et al., 2017)	Total ankle replacement in health care	TDABC	Lack of knowledge of from cost and value perspective.	-TDABC gives understanding of cost drivers.
17.	(Robert S. Kaplan & Haas, 2018)	Spine care	TDABC	Existing cost measurement is inaccurate and does not track actual resources.	- TDABC routinely collect data on standardize set of outcomes and with accurate cost information.
18.	(Zhuang & Chang, 2017)	Mixed integer programming in production process	TDABC	ABC is too simple and may not be adequate in real practice. Thus, there is need to improve ABC.	- TDABC is long-term profit oriented and multi-stage free. - TDABC attributes unused resources and provides significant information on idle capacities. Future research - Design hybrid model of ABC/TOC or TDABC/TOC and compare differences. - Strategic planning layer to be studied.
19.	(Van Dyk et al., 2017)	Radiation therapy implementation	TDABC	Understanding the factor that influence radiation therapy costing and various component costs.	- TDABC become useful tool for evaluating and optimizing radiotherapy programs.
20.	(Noain et al., 2017)	Implementation of medication review	TDABC	Analyzing costs and estimating prices.	- TDABC identified labor costs as the most important cost for the review.
21.	(Ridderstråle, 2017)	Insulin pump initiation in health care	TDABC	Need to use TDABC technique for comparison.	- TDABC is found to be effective in comparing, improving costs control and decision making.

22.	(Azar, Leblond, Ouzegdouh, & Button, 2017)	Extracorporeal photopheresis in health care.	TDABC	Need to apply TDABC technique to provide cost comparison.	- TDABC reveals better choice considering the capacity and cost implication.
23.	(French, Guzman, Rubio, Frenzel, & Feeley, 2016)	Anesthesia care for oncology surgery	TDABC	Need to have true cost and cost driver knowledge	- TDABC able to estimate the cost
24.	(Siguenza-Guzman, Auquilla, Van den Abbeele, & Cattrysse, 2016)	Academic library	TDABC	Lack of knowledge of TDABC applied in academic library	- TDABC can be used to enhance process benchmarking and providing more detailed insights. - Encourages more attention on reducing costs and accomplish outcome with fewer resources.
25.	(Yun et al., 2016)	Emergency medicine in health care	TDABC	Inaccurate costing systems is difficult to link process improvements to costs and affect the quality of outcome.	-TDABC proves that the previous costing system is inaccurate. -Collecting cost through TDABC is important for the emergency medicine.
26.	(Yu et al., 2016)	Pediatric appendectomy	TDABC	Traditional accounting poses challenges to measure the value of care costing.	-TDABC identified insufficiencies in health care delivery.
27.	(Akhavan et al., 2016)	Arthroplasty surgery	TDABC Traditional Accounting	Lack of knowledge of differences between TDABC and TA in the field	- TDABC provides more accurate measure of true resource.
28.	(Tsai, Chang, Hsieh, Tsaur, & Wang, 2016)	Joint product mix	TDABC ABC TOC	To decide best practice to reduce pollution	-TDABC accurately attribute used resources and separate idle capacity - TDABC has higher profit
29.	(Devji et al., 2016)	Pediatric surgery	TDABC	To have knowledge on most cost- effective care possible without compromising the safety and outcome	- TDABC gives out true cost of delivery care and informs changes in systematic way.
30.	(Gregório, Russo, & Lapão, 2016)	Pharmacy management	TDABC	To reduce costs while improving service standards	- TDABC gives new insights on management and costs.
31.	(Crott, Lawson, Nollevaux, Castiaux, & Krug, 2016)	Sentinel node biopsy	TDABC	To have knowledge for accurate cost-effectiveness analysis and true cost	- TDABC allows easier use of existing traditional accounting systems that do not allocate true cost.
32.	(Alaoui & Lindefors, 2016)	Treatment in depression	TDABC	To evaluate cost-effectiveness of the treatment	- TDABC is a useful tool for measuring resource costs, identifying quality improvement, and evaluating consequences.
33.	(Afonso & Santana, 2016)	Logistic process	TDABC	Need to have accurate management cost to have better decision making. TCS is not effective and does not reflect activities and processes	- TDABC allows analysis of costs and profitability. - TDABC highlighted the cost of unused capacity and effectiveness of logistics process.
34.	(Kont, 2015b)	University Library	TDABC	A need arose for standardization of the different tasks in library work both to increase production, and enhance the efficiency of human labor.	- TDABC methodology seems to be one of the best tools for understanding cost behavior and for refining a cost system for university libraries.
35.	(Waters, 2015)	Pediatric Orthopedic Surgery	TDABC	Rising health care expenditures could compromise both our country's economic stability and potentially jeopardize the availability of treatment of all the sick and injured.	- TDABC did major reduction in cost of care by reduction in practice variation.
36.	(Laviana et al., 2016)	Prostate Cancer	TDABC	Need to accurately measuring health care cost and understanding cost of producing service.	- The use of TDABC is feasible for analyzing cancer services and provides insights into cost-reduction tactics in an era

					focused on emphasizing value.
37.	(Chen, Sabharwal, Akhtar, Makaram, & Gupte, 2015)	Total knee replacement surgery	TDABC	Lack of knowledge of clinical pathways analysis and major cost drivers	- TDABD determines the major cost drivers.
38.	(Avansino et al., 2014)	Multidisciplinary reconstructive pelvic medicine (RPM) clinic	TDABC	To lower individual patient cost and optimize value in a pediatric multidisciplinary RPM clinic	-TDABC measured individualize patient costs.
39.	(Mwaikambo, Rajabifard, & Hagai, 2015)	National Spatial Data Infrastructure	TDABC	At present, models for estimating costs of access to spatial data are not easily found in the literature.	- TDABC assessing costs of access to spatial data as an empirical demonstration of tangible evidence for justification of SDIs.
40.	(Govaert et al., 2016)	Colorectal cancer surgery	TDABC	Investigating on improving quality of surgery would lead to reduction of hospital costs.	-TDABC conveys evidences for simultaneous quality improvement and cost reduction.
41.	(A. L. Kaplan et al., 2015)	Benign prostatic hyperplasia of health care	TDABC	Determining value in health care, defined as outcomes per unit cost, depends on accurately measuring cost	- TDABC can be used to measure cost across an entire care pathway in a large academic medical center
42.	(Kont, 2015a)	Print format books	TDABC	To study the acquisition cost and time optimization methods	- Drive down costs whenever possible or, alternatively, add value to the end product in cases where cost reduction was not the most important goal.
43.	(Grant, 2015)	Diabetes out-patient appointment	TDABC ABC	Unbundle the cost to provide a more accurate value for the cost object.	- TDABC generates individual cost of the patient.
44.	(Mandigo et al., 2015)	Health-care resource use in Mirebalais, Haiti	TDABC	To have knowledge of TDABC applied in resources-limited settings.	-TDABC used to calculate direct cost.
45.	(Campanale, Cinquini, & Tenucci, 2014)	Health care	TDABC	The demand for healthcare services is rising because the elderly population and chronic diseases are increasing.	- TDABC may enhance transparency and support decisions toward a better organization of work and an informed allocation of resources.
46.	(Siguenza-Guzman, Van den Abbeele, & Cattrysse, 2014)	Cataloguing process	TDABC	To have knowledge on TDABC applied to other library services.	-TDABC is a quicker and easier way of calculating cataloguing savings. - Utilizing TDABC to benchmark libraries for "best practices" is an additional prospect for future analysis.
47.	(Mortaji et al., 2013)	TDABC	FuzzyTDABC	TDABC poses some difficulties in calculations of the assigned costs. Unavailability of accurate and reliable time drivers, variety of time drivers, difficulties of collecting and updating data through calculation procedure, and huge volume of data	- It becomes possible to make more accurate managerial decisions, thereby avoiding harmful deviations. - Fuzzy TDABC is recommended in many industries when ambiguity and uncertainty in parameter estimation is encountered.
48.	(French et al., 2013)	Preoperative assessment center	TDABC	The value and impact of process improvement initiatives are difficult to quantify.	- TDABC can be applied in a health care setting. - TDABC allows for quantification of value in process improvements. - TDABC allows one to evaluate the value of identified process improvements.

49.	(Bagherpour et al., 2013)	Production planning environment	TDABC ABC	Manufacturing managers are trying to decrease production costs by focusing on activities and resource costs besides the relevant cost drivers.	- TDABC has shown a decrease in total cost in comparison with the ABC results. - TDABC results show realistic characteristics than the relevant performance obtained by ABC.
50.	(Somapa et al., 2012)	Small logistics company	TDABC ABC	ABC leads to increased accuracy benefiting decision-making, but the costs of implementation can be high	- Small firms can benefit from TDABC because of the use of simplified parameters.