EXPLORING THE ADOPTION OF ACTIVITY-BASED COSTING IN SELECTED SOUTH AFRICAN CRUDE OIL REFINERIES

by

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ABSTRACT

The South African petroleum industry is regulated, with the Department of Energy stipulating import parity as refinery product costs. Refineries may not have an exact view of actual product cost and may base decisions on deemed costs. Prior literature has not addressed refinery processes or activity-based costing in regulated environments. This study aimed to explore the opinions of selected refinery managers on refinery processes and activity-based costing adoption to inform optimal product mix decisions for selected regulated products. The empirical analysis based on semi-structured interviews determined that even though refineries allocate indirect costs to products based on volume, product mix decisions are based on the regulated price. Although the findings support activity-based costing adoption, this may not be conducive in regulated environments. Further research is required on the relationship between activity-based costing and price regulation, and how activity-based costing may impact the optimisation of the crude oil refinery value chain.

KEYWORDS:

Activity-based costing, South African petroleum industry, crude oil refineries, indirect cost, optimisation, refinery process, regulated industry, product-mix decision.

INGQIKITHI YOCWANINGO

Imboni yokusamafutha eNingizimu Afrika isingaphansi kolawulomthetho, ngokuvunyelwa wuMnyango Wezamandla okuyiwona obeka imithetho yezohwebo olungenayo ngokulinganayo nezindleko zezikhungo zokuhluza uwoyela. Izikhungo zokuhluza okusawoyela kungenzeka zingabi nayo indlela eqondile yokubuka izindleko zomkhiqizo futhi kungenzeka zigxile ezinqumweni ezizicatshangwayo nje. Okubhalwe yizazi ngaphambilini akuzange kubheke izinhlelo zokuhluza noma imisebenzi egxile ekufakeni izindleko ezindaweni ezihambisa ngokolawulomthetho. Uhlaziyo olungahambisi ngokwesayensi kodwa oluhambisa ngokubona nangokubika olusezinkulumeningxoxo ezingalandeli uhla lwemibuzo ehleliwe luthole ukuthi nakuba izikhungo zokuhluza zifaka izindleko ngokungaqondile ngqo zibe zigxile emthanyini womkhiqizo, izinqumo ezixubile zemikhiqizo zigxila entengweni ehambisa ngokolawulomthetho. Nakuba imiphumela yocwaningo yeseka ukuthathwa kwemisebenzi egxile ekufakeni izindleko, lokhu kungenzeka kungahambisani nolawulomthetho ezindaweni ezithile. Kusadingeka ukuba kwenziwe ucwaningo mayelana nobudlelwano obuphakathi kwemisebenzi egxile ekubekeni izindleko kanye nolawumthetho lwezentengo, ngokunjalo nokuthi imisebenzi egxile ukufakeni izindleko ingaba kanjani nomthelela emjikelezweni wokucoliseka kwamandla kuwoyela ongahluziwe ezikhungweni zokuhluza.

AMAGAMA ASEMQOKA**:**

Umsebenzi ogxile ekufakeni izindleko, Imboni yokusawoyela eNingizimu Afrika, izikhungo zokuhluza uwoyela ongahluziwe, izindleko ezingaqondile ngqo, ukucoliseka, izinhlelo zezikhungo zokuhluza, imboni ehambisa ngokolawulomthetho, izinqumo ezixubile zemikhiqizo

KAKARETŠO

Intasteri ya Petroleamo ya Afrika Borwa e a laolwa, le Kgoro ya Enetši e laeditša tekano ya ditšwantle ga naga bjalo ka ditshenyagelo tša ditšweletšwa tša bohlwekišetšo. Mahlwekišetšo a ka hloka pono ya maleba ya tshenyagelo ya setšweletšwa ya nnete gape a ka tšea diphetho go ya ka ditshenyagelo tše di akanywago. Dingwalwa tša pele ga se tša akaretša ditshepedišo tša bohlwekišetšo goba go hlakanya ditshenyagelo go ya ka mošomo ka mafelong ao a laolwago. Maikemišetšo a dinyakišišo tše ke go nyakišiša dikgopolo tša balaodi ba bohlwekišetšo bao ba kgethilwego mabapi le tshepedišo ya bohlwekišetšo le kamogelo ya go hlakanya ditshenyegelo go ya ka mošomo go tsebiša diphetho tša motswako wa ditšweletšwa tša go kaonafala tše di kgethilwego. Tshekatsheko ya diphihlelelo ye e theilwego godimo ga dipoledišano tšeo di sa beakanywago ka botlalo di laeditše gore le ge mahlwekišetšo a aba ditshenyagelo tše di iphihlilego go ditšweletšwa go ya ka bolumo, diphetho tša motswako wa

setšweletšwa di theilwe godimo ga theko yeo e laolwago. Le ge dikutullo di thekga kamogelo ya go hlakanya ditshenyagelo go ya ka mošomo, se ka no se thuše mafelong ao a laolwago. Go hlokega dinyakišišo tšeo di tseneletšego mabapi le kamano gare ga ditshenyagelo tšeo di hlakanyago ditshenyagelo go ya ka mošomo le taolo ya theko, le gore naa go hlakanya ditshenyagelo go ya ka mošomo go ama bjang kaonafatšo ya mekgwa ya tšweletšo ya bohlwekišetšo bja oli ye tala.

MANTŠU A BOHLOKWA**:**

Go hlakanya ditshenyagelo go ya ka mošomo, intasteri ya petroleamo ya Afrika Borwa, bohlwekišetšo bja oli ye tala, ditshenyagelo tše di iphihlilego, kaonafatšo, tshepedišo ya bohlwekišetšo, intasteri ye e laolwago, diphetho tša motswako wa setšweletšwa.

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LIST OF ABBREVIATIONS

ABC	Activity-based costing
BFP	Basic fuel price
DOE	Department of Energy
E&P	Exploration and production
FM	Financial Manager in the refinery
FOB	Freight on board
GDP	Gross domestic product
IBLC	In-Bond-Landed-Costs
LP	Linear progression
MMbbl/d	Million barrels of oil per day
NATREF	National Petroleum Refiners of South Africa
OPEC	Organisation of the Petroleum Exporting Countries
RM	Refining manager
R&M	Refining and marketing
SAPREF	South African Petroleum Refineries
TC	Traditional costing
US	United States of America
WTI	West Texas Intermediate

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

The petroleum industry is an economic powerhouse (McFarlane 2021). Nortjé (2014:3), stated that the petroleum industry is a diversified industry that not only impacts the economy and environments globally, but also individuals directly in their day-to-day activities. The industry is an important part of the global economy, providing essential energy-providing resources, including oil and gas for global advancement (IPIECA 2015:8). According to Alshubiri, Tawfik and Jamil (2020:2), the petroleum industry, especially in crude oil-producing and crude oil-exporting countries, plays an essential role in determining the country's primary source of income, therefore, making the petroleum industry's contribution to the country's economy visible.

Due to the importance of the industry in the global economy, an intergovernmental organisation to unify oil trading policies, namely the Organisation of Petroleum Exporting Countries (OPEC), was established in 1960 (Yuzbashkandi & Sadi 2020:134). The OPEC controls the crude oil supply (Alkhathlan Gately & Javid 2014:210) and thereby influences the crude oil price. The industry searches for crude oil and invests continually in finding new opportunities, addressing challenges, as well as finding new facilities, infrastructure and technology with the aim of ensuring its sustainability (IPIECA 2015:8). Compared to other industries in the South African economy, the petroleum industry plays a critical role in enabling and stimulating growth and contributing to the gross domestic product (GDP). The petroleum industry has the second greatest multiplier effect on GDP (SAPIA 2021). The petroleum industry was negatively affected by the COVID-19 pandemic, the defining feature of 2020 (OPEC 2020:47). Owing to the pandemic, the global economy dropped by 4.1% and worldwide oil demand fell by 9.7 million barrels of oil per day (MMbbl/d), which equates to nearly 10%, which negatively affected the industry (OPEC 2020:47).

The petroleum industry value chain is distributed into dissimilar segments, known as upstream, midstream, and downstream (Melton, Hudson & Ladislaw 2015:2), each with specific activities. Upstream activities include the exploration and extraction of crude oil and gas, while midstream comprises transportation and infrastructure such as pipelines and access to roads, rail, ports, as well as storage to transport crude oil to the refineries (Melton et al 2015:1-2). The downstream segment includes the refining of crude oil into consumable petroleum products, operating the refineries and determining the mix of products. All three segments are capital intensive (Melton et al 2015:2) due to the activities involved. In this capital-intensive industry, there are high operating costs which includes indirect costs due to fixed assets used in the production process, mainly including depreciation and staff costs (Cai 2018:74-75). As the industry may have higher indirect costs compared to other industries, the industry needs a costing system that accurately calculates product cost.

In the petroleum industry there are companies specialising in one segment while others are integrated, which means they have a combination of two or three segments. Melton et al (2015:2) stated that in the downstream segment, refineries, manufacturing operators, and others use about 90 million barrels of crude oil daily. Crude oil is refined into multiple petroleum products that are ready to be used as the final product by different users. The products produced jointly include liquefied petroleum gas, gasoline which is known as petrol, kerosene, jet fuel, diesel, fuel oils, sulphur, feedstock, and finished nonfuel products which are by-products. Almost half of the petroleum products refined worldwide are used by the transportation sector and the balance used for electric power, petrochemicals, buildings, and by the agriculture sector (Melton et al 2015:2).

The United States (US) has the largest refining capacity in the world (about 18 million MMbbl/d), followed by China (about 17 MMbbl/d), while African countries have 5 MMbbl/d (bp Statistical Review of World Energy 2021:31). In 2020, petroleum refineries in the US had a throughput of 14.2 MMbbl/d of refined petroleum products, followed by China which produced 13.8 MMbbl/d. African countries produced almost 1.8 MMbbl/d, which was approximately 6.5% of global throughput (bp Statistical Review of World Energy 2021:30). There are six operating petroleum refineries in South Africa with a combined capacity of 0.7 MMbbl/d (SAPIA 2019:34).

The South African petroleum value chain starts from the midstream segment with the importing of crude oil, as South Africa has a low crude reserve (SAPIA 2016:17). Thereafter, the downstream segment processes crude oil in the refineries to produce multiple petroleum products, which are then transported to depots (secondary storage facilities) or principal customers (SAPIA 2016:17). This study will focus on the refinery part of the downstream segment, because the refining process is where the indirect cost of producing petroleum products is incurred and the optimal product mix decisions are taken.

Four South African refineries are on the coast, and two inland (SAPIA 2019:34). The refineries use different raw materials, with four that refine petroleum products from crude oil, one from coal and one from gas (SAPIA 2022). This study will focus on the crude oil refineries because they have the largest capacity to produce petroleum products. For the crude oil refineries, the South Africa imports more than 99% of its crude oil and refines it to satisfy its liquid/petroleum desires (SAPIA 2019:15). In 2019, South African crude oil imports were mostly from OPEC in the Middle East and West Africa, with 39% imported from Nigeria, followed by Saudi Arabia (33%), the United Arab Emirates (11%), Angola (6%), and small volumes from various other producers (11%) (SAPIA 2019:30). South Africa refines 5% of its fuel needs from gas, 35% from coal and 50% from crude oil refineries (SAPIA IMO 2019:4). About 80% to 85% of South Africa's crude oil is imported via the single buoy mooring machine off the coast of Durban (BP 2021).

Similar to many developing countries where governments control petroleum product prices (Kojima 2013:4), the South African petroleum industry is regulated, with the price controlled by the Minister of Energy based on the Petroleum Products Act 120 of 1977 (South Africa 1977). This means that each element of the petroleum product price as well as the final price that is charged to end customers must be approved by the Minister of Energy (DOE 2018:2). In contrast, Kojima (2013:31), contends that industry regulation may interfere with cost efficiency improvement. In a study of petroleum product pricing and complementary policies in 65 developing countries, Kojima (2013:12) found that while price regulation ensures cost recovery to suppliers, it leaves little incentive for cost minimisation and effectivity improvement and can consequently enable inefficient operators to continue to exist. As the South African petroleum industry is regulated and cost recoveries are guaranteed to the petroleum companies, the accuracy of the costing of each product produced may not be carefully analysed as there is no incentive for cost minimisation (Crompton, Sing, Filter & Msimango 2020:4). A system that produces accurate product costs may minimise certain product costs, inform product mix decisions and provide companies with a competitive advantage. This study will therefore focus on two regulated, high value, petroleum products, namely petrol and diesel.

The selling price of petroleum products is controlled by government, hence the costing of refined petroleum products from South African refineries is based on the basic fuel price (BFP) which is an import parity plus the transportation cost from the source country to South Africa (DOE 2018:3). In other words, the BFP is the cost of purchasing petroleum product from international refineries plus the transportation cost to South African shores. Mondliwa and Roberts (2014:553) state that the BFP replicates the accepted reasonable cost of importing a litre of petroleum product of a comparable quality from worldwide refineries to a nearby South African shore. Being an import parity, the BFP is deemed a product cost, and therefore, excludes local refining operations and costs. Rustomjee, Crompton, Maule, Mehlomakulu and Steyn (2007:153) also question whether the BFP accurately reflects international petroleum product prices. Mokoena and Lloyd (2005:10) claim that the BFP for diesel is “around 10 cents per litre greater than the true import parity price”. Although 10 cents per litre may be beneficial to the industry, it raises a question of the accuracy of the deemed product cost used by refineries for various refined petroleum products. The issue of import parity accuracy has been acknowledged by the Department of Energy (DOE). The DOE has gazetted a 2018 document to review the BFP’s relevance (DOE 2018:3-10). In addition, the Minister of Finance in South Africa has called for a review of the petroleum price calculation (Vecchiatto 2021).

The BFP is used as the transfer price between refining and marketing, which is then also used as the deemed cost of the petroleum product (Adeosun & Oluleye 2017:1). As OPEC controls international oil prices, refineries have limited control over the input cost of crude oil, hence, the importance of optimising to gain operational effectiveness to increase profitability and achieve a competitive advantage (Adeosun & Oluleye 2017:1). This entails reducing indirect costs such as labour and energy (electricity and natural gas) (Adeosun & Oluleye 2017:1). It is therefore argued that to reduce the operating cost, the industry needs to first fully understand the activities that drive costs which will then allow the accurate determination of product costs. As the transfer price is deemed to be the cost of sales for the refined petroleum products sold, the BFP does not take the indirect costs of refineries into consideration. Hence, all the activities that comprise the total indirect costs may not be factored into the costing of refined petroleum products, which affects the accuracy of the petroleum product cost. Relying on actual costs per product, which include an allocation of indirect costs, rather than a deemed BFP cost, could form the basis for optimal product mix decisions. It appeared that selected South African crude oil refineries do not use a costing system that accurately allocates indirect costs to the various products to ensure accurate product costing. Therefore, the adoption of an ABC system which allocates indirect cost more accurately may provide South African crude oil refineries with accurate product cost to subsequently inform optimal product mix decisions.

1.2 LITERATURE REVIEW

Activity-based costing (ABC) is an accounting system that classifies and assigns indirect costs to cost activities and then allocates those costs to products, while a traditional costing (TC) system tends to use an arbitrary basis of allocation of indirect cost such as volume or hours (Drury 2018:268). Drury (2018:268) describes ABC as a system which identifies activities and allocates the indirect cost of each activity to all products based on the real consumption. Cooper and Kaplan (1998:66) revealed that ABC was created to obtain a more accurate cost of products. The most significant difference between ABC and TC is in the allocation of indirect costs (Cooper & Kaplan 1998:66). The TC system allocates indirect production costs to the products produced on the basis of volume, labour hours, or machine hours (Banker, Bardhan & Chen 2008:3). On the other hand, ABC recognises the interdependencies of cost drivers which are transaction-based, and allocates indirect cost based on activities (Mahal & Hossain 2015:71). In summary, ABC identifies the activities and allocates indirect costs based on those activities compared to TC which ignores the activities and assumes that all products incurred the same indirect cost.

The ABC system emerged from an increasing need for an accurate allocation of indirect cost not available from the TC systems (Salem & Mazhar 2014:6). An ABC system aims to complement traditional accounting and financial systems and is not a substitute for existing systems (Miller 2017:25). The data produced from an ABC system compared with the TC system, shows that ABC can significantly minimise the product cost distortion resulting from an unsystematic allocation of indirect costs (Dwivedi & Chakraborty 2016:1). This means that ABC may be used as a cost management system which may lead to less cost distortion and more accurate product cost.

Regarding benefits, ABC is a costing system that provides more accurate product costs than a TC system (Ping & Yu 2013:3195; Salem & Mazhar 2014:4) and which improves cost control (Salem & Mazhar 2014:4). Lal (2009:332), adds that in the advanced manufacturing environment where indirect costs constitute a large portion of the overall costs, ABC has increased operational performance. While the benefits of ABC have been recognised, some disadvantages are associated with the system. ABC costs more to maintain than a TC system and the implementation of an ABC system is complex for managers to understand, hence the decision making from ABC may take time (Mahal & Hossain 2015:71). Notwithstanding its disadvantages, the benefits of adopting an ABC system are tangible.

The overview on the use of ABC commences with two recent systematic literature reviews. In a review of 27 ABC articles published from 1989 to 2015, which focuses on the analysis of the implementation, adoption and impact of ABC, Lueg and Storgaard (2017:11-13) found that the majority of studies were completed in large manufacturing companies in developed countries and used contingency theory and factor analysis, with two studies using actor network theory and one using institutional theory as a theoretical lens. Therefore, optimisation theory was not evident in the ABC studies reviewed. However, an empirical study by Singer and Donoso (2007:344) on an activity-based optimisation system, is discussed further in Chapter 3. Optimisation theory is the method of identifying the best variables from the specific scenario to maximise or minimise the expected results (Saremi, Mirjalili & Lewis 2017:30). Based on the recognised categories of limitations, constraints, and number of appropriate objectives, the optimal point should be selected and used to obtain the best results from the specific scenario (Saremi et al 2017:30). It therefore appears that ABC may be used in conjunction with optimisation theory to optimise the complex production process and take subsequent optimal product mix decisions.

Secondly, Terzioğlu and Chan (2018:116) included 183 ABC articles worldwide from 2001 to 2011. They stated that the majority of the ABC studies were from developed countries like the US, followed by Australia and the United Kingdom – and that research interest in ABC studies is continuously decreasing. The fact that ABC has been well studied in developed countries may explain the decline in the number of recent studies, however, Terzioğlu and Chan (2018:132) suggest that further research should be conducted to investigate reasons for this decline. The basics of ABC as a system for allocating indirect costs to cost objects, such as products or customers, has been studied as a principal costing system that calculates accurate product costs in different industries (Kumar & Mahto 2013:1). The ABC is implemented across many industries, sectors and institutions (Kumar & Mahto 2013:1), in both developed and developing countries.

The overview below commences with recent studies in various sectors or industries in developed and then developing countries. In a study of a public sport organisation in Greece, the cost of athletic activities was more accurate using the ABC than the TC system, which undervalued or overvalued some product costs (Kosmas & Dimitropoulos 2014:130). Miller (2017:22) adds that ABC accurately calculates the delivery cost of logistics companies in America. Based on a study of ABC as an effective tool for the performance of manufacturing companies in Europe, Mahal and Hossain (2015:71), state that ABC allocates indirect costs accurately and leads to less cost distortion. The study of Almeida and Cunha (2017:939) in a manufacturing company in Portugal, revealed that ABC adapts to the needs of a company and provides accurate and useful information such as a product cost price.

Lueg and Storgaard (2017:18) contend that there are few research studies on ABC in developing countries. Studies in various developing countries found that the use of ABC resulted in more accurate product cost. These include Hajjawi (2017:99) on ABC practice for decision-making in Palestinian companies, Yang and Chang (2018:57) on the application of ABC to the green industry for profitability and performance in Taiwan, and a Malaysian study in the agricultural sector, which states that ABC produces actual accurate cost information and proper cost activities (Wen-Zheng & Yazid-Abu 2019:10). Similar benefits were found in two studies conducted in India, with Salem and Mazhar (2014:44) on ABC in manufacturing companies and Dwivedi and Chakraborty (2016:297) on the adoption of ABC in a steel plant. The study by Sembiring, Wahyuni, Sinaga and Silaban (2017:6) focused on ABC implementation for palm oil production in Indonesia, considering value-added and non-value-added activity. They found that the ABC system calculated product cost more accurately and reduced product cost distortion compared to TC. Lastly, Cai (2018:104) that focused on the cost drivers for the petroleum industry in China, revealed that ABC identifies cost drivers to improve the costing strategy. Kojima (2013:40) stipulated that China’s petroleum industry prices are not regulated.

Similar to what was found for developing countries, Elhamma (2015:1) contends that ABC studies are almost absent in Africa, although there are a few recent examples. A study by Ezeagba (2014:12) on ABC and organisational performance in two manufacturing companies in Nigeria, stated that ABC identifies cost drivers to produce accurate product cost. The empirical evidence from 62 companies from different industries in Morocco shows that the adoption of ABC increases competitiveness and profitability (Elhamma 2015:73, 85). Ali, Malo-Alain and Haque’s (2015:605) study on the impact of ABC on companies’ performance in Saudi Arabia, found that ABC may be used for cost control, as it allocates indirect cost accurately. Furthermore, Osetoba, Barinyima and Amadi

(2019:49) conducted a study on the impact of ABC in reducing crude oil production cost in a Nigerian indigenous oil and gas company and stated that ABC reduces non-value adding cost.

There are few studies done in South Africa on ABC. Reynolds (2013:6) in a study of factors influencing the success of ABC in the Nelson Mandela Bay Metropole manufacturing industry stated that there are fewer studies that deal with the primary subject of ABC within the South African literature and that research studies specifically on ABC success aspects are scarce. More recently, studies done in the public sector context in South Africa showed that ABC ensures that costs are captured more accurately and allocated to the correct activity that causes the cost. These include Oseifuah (2014:586) on the benefits and challenges of using ABC in the South African public sector, Botha and Du Toit (2017:351) on the South African health sector and the adoption of ABC in private health care facilities and Bvumbi (2017:81) performed an analysis on the implementation of ABC in a water trading entity in South Africa. Madwe (2017:223) studied the adoption of ABC in the education sector in the KwaZulu-Natal Province, South Africa, stated that ABC adoption gives an accurate allocation of the indirect cost which leads to accurate product cost and can be used for cost control. In these studies, ABC was found to allocate indirect costs accurately based on activities to the specific product or service.

As no studies have been found on ABC in a regulatory environment, this points to a gap in the literature. Furthermore, in a country like South Africa with regulated petroleum pricing, it appears that the adoption of ABC may be used to identify cost drivers to improve costing strategy and calculate more accurate petroleum product costs. The study by Osetoba et al (2019) in Nigeria, was on the upstream crude oil production cost, it is argued that the same principle of reducing non-value adding cost may be applied downstream to the refined petroleum product cost. Therefore, the gap in the literature identified on the regulated market in the downstream segment where crude oil refineries are operating remains. In South Africa, there are limited ABC studies in the private sector, manufacturing, petroleum industry and regulated industries in South Africa. Therefore, this study will add to the South African petroleum studies in ABC from a regulated industry.

The study therefore aims to reduce the identified gap in the ABC literature by focusing on selected South African crude oil refineries in the downstream segment of the petroleum industry. Hence it will contribute to the existing body of knowledge by providing insight on ABC in a regulated industry, in a developing country and in Africa.

1.3 PROBLEM STATEMENT

Section 1.1 of this study explained the importance and provided a contextual background to the petroleum industry. The petroleum industry value chain is a capital-intensive industry with different segments such as upstream, midstream, and downstream. The South African petroleum industry focuses on the downstream segment as South Africa has small crude reserves. The product cost for the refined product is based on the import parity, as if there are no refineries in South Africa, known as the BFP. This means that the cost used for the product cost is not the actual cost of producing the petroleum product in South African refineries, but a deemed cost. The South African petroleum industry is regulated, and the DOE stipulates the pricing of petroleum product by using the BFP as the base for the product cost. This cost is used as the transfer price from refineries to market to calculate the cost of the product. This means the full value chain may over- or under-state the cost of the product. The industry may not have an accurate view of the exact petroleum product cost; therefore any subsequent product mix decisions may currently be based on the deemed cost.

Section 1.2 states that ABC allocates indirect costs to products based on the activities and identifies non-value and value adding activities. Salem and Mazhar (2014:4) stated that ABC can be used for improved cost control and multiple studies indicated its use to calculate product cost more accurately. Despite the various research studies done on ABC, Lueg and Storgaard (2017:18) concluded that there is little research done on ABC in developing countries, Elhamma (2015:73) added that the ABC studies are almost absent in Africa, while Kumar and Mahto’s (2013:21) systematic review study stated that ABC can be used in every type of industry and country. Using optimisation theory as a lens for this study in conjunction with ABC, the South African crude oil refineries may potentially obtain more accurate product costs that could inform optimal product mix decisions based on the costing information.

The problem statement may be formulated as follows:
South African crude oil refineries do not appear to use a costing system that accurately allocates indirect costs to the various products to ensure an accurate product cost per product, instead they use the BFP as a deemed cost for each regulated petroleum product produced.

1.4 RESEARCH AIM AND OBJECTIVES

The aim of this study is to explore the managers’ opinions on ABC adoption considerations and refinery processes to subsequently inform optimal product mix decisions of selected regulated petroleum products in South Africa.

The aim will be accomplished by means of the following objectives:

1. Review the crude oil refinery value chain, considering the deemed cost of selected regulated products in South Africa
2. Investigate the concepts generally associated with an ABC system, considering ABC through the lens of optimisation theory
3. Explore the refinery processes in determining the optimal product mix and effect of COVID-19 in selected South African refineries
4. Explore the refinery managers’ opinions on the costing currently used and ABC adoption considerations for the selected regulated petroleum products in South Africa

1.5 THESIS STATEMENT

Rather than relying on the BFP as the product cost for selected regulated petroleum products, ABC adoption by South African crude oil refineries may lead to more accurate indirect cost allocations and product costs which better informs their subsequent product mix decisions.

1.6 DELINEATION AND LIMITATIONS

The research study will be delineated to the South African crude oil refineries, part of the downstream segment of the petroleum industry value chain. More specifically, the research study will focus on two crude oil refineries, one coastal and one inland, namely South African Petroleum Refineries (SAPREF), and National Petroleum Refiners of South Africa (NATREF), respectively. The main reason for choosing these two refineries is to have a view of ABC for coastal and inland costing as well as because SAPREF has the largest crude oil refining capacity and NATREF is the only full-conversion refinery in South Africa.

Furthermore, the study focused on two high-value regulated products which use the BFP as a deemed cost, namely diesel and petrol. The study was conducted using qualitative methodology with semi-structured interviews. The empirical data of the study was limited to the participants' responses from the two crude oil refineries.

1.7 DEFINITION OF TERMS AND CONCEPTS

ABC is an acronym for activity-based costing, which is an accounting system that classifies and assigns costs to indirect cost activities and then allocates those costs to products (Drury 2018:267).

Activities are the collection of numerous distinct actions, processes, or series of tasks that result in resource consumption (Drury 2018:276).

Basic Fuel Price (BFP) is the South African regulated fuel price that is determined by the cost to a South African importer of purchasing petrol from a foreign refinery and transporting it to South African ports (SAPIA 2022).

Cost driver is the basis used to allocate costs to cost objects in an ABC system (Drury 2018:276).

Downstream segment (petroleum industry) is the refining and marketing of the refined petroleum product where, in the refining process, crude oil is converted into a variety of useful products (Melton et al 2015:2).

Indirect costs are expenditures that cannot be linked to a specific cost unit in a definite and exclusive manner (Nasution & Siregar 2018:2).

Midstream segment (petroleum industry) is the transportation, storage, and wholesale marketing of crude or processed petroleum products through pipeline, and by rail, oil tanker or truck (SAPIA 2016:16).

Optimisation is doing the most with the least (Gomez, Oakes & Leone 2006: 301), the process of determining the most favourable or effective value (Lockhart & Johnson 1996:610).

Traditional costing (TC) system is defined as the system that allocates indirect cost to products based on the volume of production or direct labour hours consumed or machine hours used (Drury 2018:267).

Upstream segment (petroleum industry) covers the exploration and production of crude oil (Melton et al 2015:2; O'Driscoll 2016:45).

1.8 RESEARCH METHODOLOGY

Methodology is the term used to indicate how we look at the problem scenario and find ways to tackle the problem (Taylor, Bogdan & DeVault 2016:3). As detailed in Chapter 4, there are different methodologies to be used in finding answers, one being a qualitative approach. Greener and Martelli (2015:22) state that qualitative research is associated with an approach that looks at the research problem first to create a theory, often using an interpretation of the scenario by analysing the existing various subjective views. Taylor et al (2016:7) added that qualitative researchers focus on what they individually see as the meaning and interpretation of the scenario at hand. Therefore, the qualitative approach was adopted for this study as it gathered the information from participants based on their experience and understanding of the crude oil refineries and ABC. The following section will discuss the research design of the study.

1.8.1 Research design

A research design that shows a study as ‘qualitative’, demonstrates a concern with ‘what’ ‘why’ and ‘how’ questions (Ritchie, Lewis, Nicholas & Ormston 2013:4). Therefore, the interview questions were posed to the participants who are the managers in the refineries and this method led them to give a broader perspective on the aspects explored. Ritchie et al (2013:4) argue that detailed information-generation approaches, such as semi-structured interviews, may be used for qualitative research. In addition, Taylor et al (2016:31) revealed that a study that shows an in-depth understanding of the specific topic and overall theoretical understanding of a specific scenario or event is classified as a good qualitative study. Thus, this study adopted the qualitative approach to demonstrate an in-depth understanding of the crude oil refineries processes used to determine the optimal petroleum product mix and the participants’ opinions on the current costing and ABC adoption considerations.

1.8.2 Literature review

The literature review includes studying the contextual background as well as nationally and internationally published scholarly literature on ABC. In meeting objective 1, which was to review the petroleum refinery value chain, considering the deemed cost of selected regulated products in South Africa, the applicable information was firstly gathered from international and local scholarly articles and theses. Secondly, to fully understand the contextual setting of the study, up-to-date information was gathered from grey sources such as industry documents, accounting papers and internet websites such as those of SAPIA, DOE, and IPIECA.

In meeting objective 2 which is to investigate the concepts generally associated with an ABC system, considering ABC through the lens of optimisation theory, scholarly journal articles, books, theses and dissertations focusing on ABC were used.

1.8.3 Empirical study

The empirical research was carried out to meet objective 3, which was to explore the refinery processes in determining the optimal product mix and effect of COVID-19 in selected South African refineries, and objective 4, which was to explore the refinery managers' opinions on the costing currently used and ABC adoption considerations for the selected regulated petroleum products in South Africa. The following subsections describe the approaches used.

1.8.3.1 Research instrument

Research instruments are tools intended to obtain information on a subject of interest, and in a qualitative study, the researcher is also the research instrument (Yilmaz 2013:317). The researcher should create close interaction with the research partakers when gathering information (Yilmaz 2013:317). According to Stuckey (2016:56), semi-structured interviews allow for flexibility whereby the researcher determines the subjects to be discussed, but the participants' responses determine how the interview is conducted. Semi-structured interviews were used as it allowed the participants to share their detailed knowledge about objectives 3 and 4, indicated above.

Taylor et al (2016:123) contend that an interview guide ensures that all similar participants are asked the same questions and that participants focus on the same scenarios. It is advisable to prepare the open-ended and descriptive questions before the interview. For interview efficiency, the questions were arranged into two interview guides, each tailored to a particular group of participants. The interview guides were prepared in advance and used as the information gathering tool to ensure that the same open-ended questions were asked to all participants.

1.8.3.2 Target population and sampling

The target population is the whole combination of respondents that meet the selected set of standards (Burns & Grove 1997:236). The four crude oil refineries had 16 potential managers to interview, 12 of whom were from SAPREF and NATREF, the selected crude oil refineries. According to Taherdoost (2016:20-22), a non-probability selection allows the researcher to aim for exact people with sufficient knowledge on a specific subject. Therefore, a non-probability selection process was used to choose participants since it permitted the researcher to aim for exact people with sufficient knowledge on a specific subject. Ten of the 12 managers employed by the petroleum companies that operate SAPREF and NATREF were sampled. Seven interviews were conducted collectively with financial managers (FMs) and refinery and optimisation managers (RMs) as discussed in Chapter 4.

1.8.3.3 Data collection

Data collection is "a systemic way of gathering information, which is relevant to the research purpose or questions" (Burns & Grove 1997:383). The interviews with the sampled managers were conducted online via Microsoft Teams. According to Taylor et al

(2016:130) audio recordings circumvent misunderstandings, guarantee clearness on all topics, and allow the interviewer to record the conversation in order not to have to rely on memory. Therefore, the seven semi-structured interviews were audio-recorded to ensure that all the responses from the participants were taken into account and not misunderstood.

1.8.3.4 Data analysis

Data analysis is a dynamic and unique method to gain a profound understanding of what you have considered and to continually improve the understanding (Taylor et al 2016:169). For this study the data analysis of the transcribed interviews was done by means of thematic codes using Atlas.ti™ version 9. According to Saldaña (2013:4) coding is a “word or phrase” that summarises a portion of language-based data. Creswell (201:156), however, explained coding as the act of deconstructing qualitative text data to discover what it yields before reassembling the data in a useful way. The data were coded by the researcher and the second coder to ensure accuracy of the data analysis. Data were examined by means of the continuous comparative method whereby lines, sentences and paragraph segments of the transcribed interviews were studied to select the codes appropriate to the theories suggested by the data. The interview data were also placed in context with supporting literature.

1.9 ETHICAL CONSIDERATIONS

Pera and Van Tonder (1996:4) define ethics as “a code of behavior considered correct”. It is vital that all scholars are aware of research ethics. According to Nurse (2016), ethics relate to two groups of people; those conducting research, who should be aware of their duties and accountabilities, and the “researched upon”, who have basic rights that should be protected. Prior to conducting the research study, permission was obtained from the Research Ethics Review Committee of the College of Accounting Sciences at UNISA. The study was conducted with objectivity and fairness by removing all possible threats. The participants were made aware of their rights. As stated by Brink and Wood (1998:200-

209) ethical issues observed in the study will include "informed consent, right to anonymity and confidentiality, right to privacy, justice, beneficence and respect for persons", which were observed as described in Chapter 4.

1.10 SIGNIFICANCE OF THE STUDY

Practically, this research study explored the opinions of the managers on the South African crude oil refinery processes in determining the optimal product mix in the selected refineries, the costing currently used, ABC adoption considerations for the selected regulated petroleum products in South Africa, and the human intelligence role on the crude oil refinery adaptation to disruptions brought about by COVID-19. On a practical level, the information from the research study is primarily intended for the management of the South African crude oil refineries so that they can ascertain the costs of each product, and thereby be equipped to make informed decisions about petroleum product costing that may further inform subsequent product mix decisions. Theoretically, this research study will reduce the gap in the ABC literature in developing countries in Africa, for regulated industries, and the petroleum industry.

1.11 CHAPTER OVERVIEW

CHAPTER 1: INTRODUCTION

The first chapter serves as an introduction to the research study. The chapter includes the background to the petroleum industry, the ABC literature review, and the study problem statement. This is followed by the research aim and objectives, thesis statement, as well as the delineation and limitations of the study. Lastly, it lists the definitions of terms and concepts and discusses the research methodology, ethical considerations and significance of the study.

CHAPTER 2: THE CRUDE OIL REFINERY VALUE CHAIN AND THE DEEMED COSTS OF REGULATED PRODUCTS IN SOUTH AFRICA

This chapter provides the contextual setting of the study. This chapter describes the background to the petroleum industry, the petroleum industry's contribution to the countries' economies, followed by the petroleum industry value chain. Then it discusses the refineries operating cost and margins. Lastly, it describes the South African deemed petroleum product cost and margins in the crude oil refineries.

CHAPTER 3: AN ACTIVITY-BASED COSTING SYSTEM IN SOUTH AFRICAN REFINERIES

This chapter examines the scholarly literature on ABC. Firstly, it discusses the need for more accurate and relevant cost information, followed by the ABC background and concept. Then it discusses the advantages and disadvantages of ABC, the factors to be considered when implementing ABC, steps for the successful implementation of ABC. The ABC implementation key success points is followed by the benefits derived from ABC adoption. Lastly, it describes the ABC through the lens of optimisation theory.

CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

Chapter 4 focuses on the research methods, procedures and techniques. The chapter defines the research approach. Then it gives an overview of the paradigms, followed by the research design and elements of the research methodology. Thereafter, it defines the validity, reliability and trustworthiness of the study, followed by the limitations of the study. Lastly, it outlines the ethical considerations.

CHAPTER 5: RESEARCH ANALYSIS AND FINDINGS

The chapter discusses the research findings and data analysis. It explains the process of coding, followed by the codes, categories and themes. Lastly, it discusses the analysis of outcomes under each theme, with the related subthemes.

CHAPTER 6: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter provides a summary of the research study followed by the main findings on each objective. It then reaches a conclusion on the study aim. It includes the study's research limitations, recommendations, and suggestions for further studies.

CHAPTER 2: THE CRUDE OIL REFINERY VALUE CHAIN AND THE DEEMED COST OF REGULATED PETROLEUM PRODUCTS IN SOUTH AFRICA

2.1 INTRODUCTION

In Chapter 1, an introduction to the research study was given, which included the context, the gap identified in the literature, the problem statement, as well as the research aims and objectives. A summary of the approach, limitations, significance of the research, and chapter descriptions of the study were also included.

In order to meet objective 1, which is to review the crude oil refinery value chain considering the deemed cost of selected regulated products in South Africa, this chapter will describe the national and international crude oil refinery value chain. It also describes how South African refineries currently calculate the costs of petroleum products based on the BFP methodology.

This chapter will provide an analysis and background to the petroleum industry and will discuss the emergence of the industry. This will be followed by how the industry contributes to the country's economy and an overview of the petroleum industry value chain. It will also discuss the crude oil refineries, followed by the international operating cost and margins of the refineries. Finally, it will discuss the South African deemed petroleum product cost and margins in the crude oil refineries.

2.2 BACKGROUND TO THE PETROLEUM INDUSTRY

The subsections will firstly introduce the emergence of the petroleum industry, mainly focusing on when crude oil was discovered in selected regions. Secondly, the background on when the refineries were established is then discussed.

2.2.1 The emergence of the petroleum industry

It is not known precisely when humans initially used petroleum products, but crude oil has been used for lighting purposes for many years (Devold 2013:1). As early as 1745, there was primitive oil production in Ukthta, Russia (Krems 2014). Petroleum products' relevance to humanity surged in the late 1800's when it was used as the main fuel, instead of coal, for machines used in the industrial revolution (Fagan 1991:vi). In 1846, the new era of the petroleum industry began when Abraham Gesner, a Canadian geologist, discovered that oil may be refined to make petroleum products, and that kerosene could be drawn off and used (Armentano 1981:55). Crude oil was discovered in 1855 in springs and seeps close to Osawatomie and Paola in the US (Junge 2010:1), while two years earlier, in 1853, the first commercial discovery in Europe was made in Poland (Craig, Gerali, MacAulay & Sorkhabi 2018:1). Before the introduction of mechanical drilling rigs in 1860, there were more discoveries of oil wells in different European countries such as Romania in 1857, Germany in 1859, and Italy in 1860 (Craig et al 2018:1). In Britain, the first oil field was discovered at Hardstoft in 1919 (Craig et al 2018:1), while in Russia the first oil well exploration occurred in 1870 (Krems 2014). In the Middle East, as early as 1938, Saudi Arabia had the first crude oil production (Shammas 2000:78) with Oman first discovering oil in 1964 (Britannica 2020).

In Africa, Nigeria, in West Africa, is the oldest crude oil-producing country. Crude oil was discovered in Nigeria as early as 1908 when a German company, Nigerian Bitumen Corporation, drilled 14 wells in Lagos (Nyemah 2011:44-45). In North Africa, the first crude oil well was discovered in 1950, and in 1952 the first exploration test was done in Algeria (Traut, Boote & Clark-Lowes 1998:69). By 1996, the oil reserve in Algeria was estimated at 46 billion barrels (Traut et al 1998:69).

Crude oil was initially drained and poured into containers to be sold as a medication, but then the importance of the petroleum industry was realised (Junge 2010:1). Crude oil started to be used as the fuel for steam engines in 1859 when "Colonel" Edwin Drake drilled the primary operative crude oil well with the intention of finding crude oil (Devold

2013:1). The Drake Well stood in farm country in north western Pennsylvania, US, and the crude oil was stored in a wooden tank (Devold 2013:1). Discovering, drilling, and removing crude oil was the start of the petroleum industry (Junge 2010:1). OPEC, the leading oil organisation established in 1960, accounts for 41.1% of global petroleum production and 79.4% of the proven world reserves in 2018 (OPEC 2021). The members of OPEC include countries from across the world with high crude oil reserves (Yuzbashkandi & Sadi 2020:134).

With the discovery of crude oil, there were multiple refineries built around the world to process crude oil into petroleum products. The section below will discuss the background to crude oil refineries.

2.2.2 The background to the refineries

As a result of the discovery of crude oil in the 1850s, several refineries were built to refine the crude oil into petroleum products (Fagan 1991:2). The development of refineries in Europe started in 1840 with a refinery in Lucăceşti, Bacău County, in Romania, the only country which had commercial-scale refining activity, followed between 1840 and 1856, with another refinery built in the Prahova area in Rafov (Craig et al 2018:7). There were four more refineries built in Bacău between 1857 and 1862 (Craig et al 2018:7). The development of small artisanal refineries in European countries thus took place at the beginning of the nineteenth century (Craig et al 2018:7).

In the US, the first region to develop a refinery was north western Pennsylvania in 1865 (O'Driscoll 2016:15). However, that refinery was closed, and then in 1905 the Paola Refining Company constructed the Sunflower State Refinery in Niotaze, Kansas (O'Driscoll 2016:15). Between 1904 and 1910, 16 refineries were built in different cities in the US (Junge 2010:4). In 1977, the last refinery in the US was opened. A total of 150 refineries have been shut down as part of an industry-wide restructuring from the mid-1980s, while the remaining refineries have increased their operating capacity by 23% to meet the rising demand for refined petroleum products (Andrews, Lattanzio, Pirog, Werner & Yacobucci 2014:4). In Saudi Arabia, the oldest refinery, called Ras Tanura, started operating in 1945, and has been upgraded over time to meet demand (Shammas 2000:30). About two decades ago, Saudi Arabia had eight refineries (Shammas 2000:29).

Until 1954, Africa did not have any refineries, and therefore, all refined petroleum products were imported from European and American refineries (Mbendi 2018). In 1954, the first two refineries in Africa were built in Algeria and Durban, South Africa. From 1954 to 2004, 48 additional refineries were built in Africa. While between 1999 and 2002 there were only two refineries built in Africa, in Khartoum, Sudan, in 2001 and the Middle East Oil Refinery near Alexandria, Egypt, in 2002 (African Development Bank and the African Union 2009:49).

There are four major refining centres in Africa, situated in Nigeria, Egypt, Algeria and South Africa. Nigeria has three refineries, Egypt has nine, Algeria has four major refineries and South Africa has four crude oil refineries (African Development Bank and the African Union 2009:49). Engen Refinery (ENREF), the first crude oil refinery in South Africa, was built in 1954 by Mobil (now Engen Petroleum) in Durban. In 1963, the SAPREF refinery was commissioned in Durban, while the Caltex refinery (CALREF) was commissioned in 1966 near the coast in Cape Town. In 1971, Sasol Mining (Pty) Ltd and Total South Africa formed a joint venture which built and operated the NATREF refinery in Sasolburg (Mbendi 2018).

There have been multiple crude refineries commissioned in the world to refine crude oil to petroleum products with the emergence of the petroleum industry. The section below will discuss the contribution of the petroleum industry to the economy.

2.3 THE PETROLEUM INDUSTRY’S CONTRIBUTION TO THE ECONOMY

Crude oil is the main source of energy in the world, with the economies of some countries highly reliant on crude oil and petroleum products (Humbatova & Hajiyev 2019:1). Crude oil is not a renewable resource (Cai 2018:4). Only certain regions in the world have the crude oil used in the petroleum industry; therefore, the emergence of an international petroleum industry was fast-tracked by economic globalisation (Cai 2018:4). The petroleum industry is one of the most productive and dynamic industries, with people using more than 4 165 million tons of crude oil annually (bp Statistical Review of World Energy 2021:19). It has been shown that a country's energy consumption may raise the country's GDP and that the rate of growth of energy consumption is comparable to the rate of economic growth of the country's economy (Afgan, Gobaisi, Carvalho & Cumo 1998:239).

In 2020, the Coronavirus (COVID-19) brought about unprecedented changes to the world and affected almost all industries including the petroleum industry, as crude oil demand fell sharply as a result of the global COVID-19 pandemic (bp Statistical Review of World Energy 2021:3). COVID-19 has negatively impacted different countries GDP's. Global industrial production was reduced as a result of the COVID-19 pandemic, resulting in reduced crude oil demand, and lowering crude oil unit prices (Aloui, Guesmi & Hchaichi 2020:5).

According to the American Petroleum Institute (2018:1), the petroleum industry in America contributes 10.3 million jobs and nearly 8% of the US GDP (American Petroleum Institute 2018). However, in Oman, a country situated on the Arabian Peninsula, the petroleum industry contributed 37% of the GDP in 2018 (Times of Oman 2019), while in Canada the petroleum industry contributed $108 billion (8%) to GDP in 2018 (CAPP 2019). In Africa, in 2017, Angola's crude oil and natural gas sector contributed about 30% of the country's GDP, 95% of total exports, and 52% of total fiscal revenue (US EIA 2019), while in Nigeria, the oil sector contributed 8.5% of GDP in quarter two of 2018 (NBS 2018). According to SAPIA (2018:6), the South African petroleum industry contributes 3.2% of the national GDP and produces 247 772 indirect jobs. The industry is a key enabler to the economic growth of the country (SAPIA 2019:5).

The petroleum industry therefore contributes positively to the GDP of different countries, hence, by developing the industry, the country's economy may improve. The value chain of the petroleum industry consists of three different segments, which will be discussed in the following section.

2.4 THE PETROLEUM INDUSTRY VALUE CHAIN

Within the modern petroleum industry value chain, there are three segments, namely upstream, midstream, and downstream (O'Driscoll 2016:44), as illustrated in Figure 2.1.

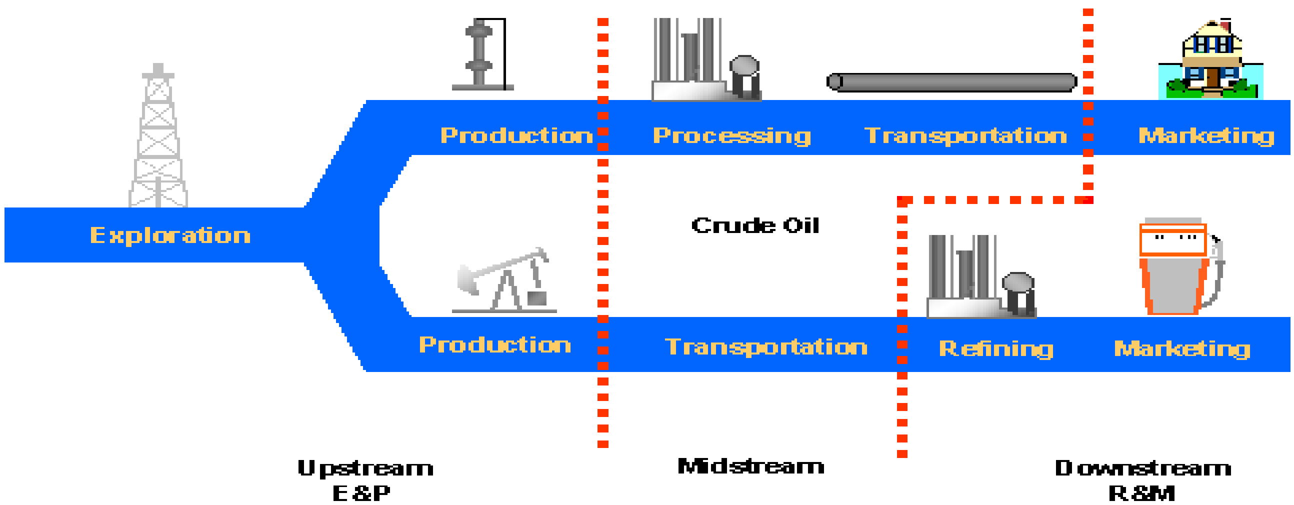


Figure 2.1: Petroleum industry value chain
Source: O'Driscoll (2016:45)

In Figure 2.1, it is apparent that each of the three segments identified has various activities. The upstream segment mainly revolves around the exploration and production (E&P) of crude oil, while the midstream segment mainly deals with the transportation and storage of crude oil. The downstream segment refines the crude oil, distributes, and markets the petroleum product (R&M) to the end customer. In the following sections the segments and activities of the petroleum industry value chain will be discussed.

2.4.1 The upstream segment

Upstream is the first segment of the petroleum industry value chain. The upstream segment also recognised as E&P, involves the search, exploration, as well as extraction of crude oil and natural gas (Holle, Huurdeman & Rozhkova 2019:3). The segment includes activities such as exploring new underwater or underground oil and gas deposits, as well as drilling wells that extract or deliver crude oil and raw natural gas to the surface (Holle et al 2019:3). The paragraphs below will discuss the main activities involved in the upstream segment in more depth.

Discovering the appropriate area to conduct exploration for crude oil and gas is the beginning of the upstream segment. Aerial and satellite photography, as well as magnetic surveys are used to discover crude oil or gas from underground or underwater sources (Devold 2013:19-31). Should the analysis show positive results, the team starts the process of applying and negotiating for exploration rights with the national authorities (Holle et al 2019:3-4). Over multifaceted computer analyses, the information is interpreted to generate an image of geological structures underground or underwater, which can include deposits of hydrocarbons. When an appropriate structure is identified, the only way to find out if hydrocarbons are indeed present, is by drilling and the exploration of a well (Holle et al 2019:3-4). The drilling equipment most suitable for the identified area is used, be it land, shallow water, or deep water (Holle et al 2019:4).

Most petroleum companies normally outsource the drilling activity as it requires different specialised equipment, products and services (Kombe 2015:66). Provided that sufficient volumes of crude oil are discovered, the operation proceeds with the drilling of one or more assessed wells to further assess the quality and size of the reserve crude oil, and hence the discovery's economic viability. If the assessment process remains viable, drilling and infrastructure work to connect the wells to local processing facilities or routes to carry the crude oil from the wells to the storage facility will occur (Holle et al 2019:4).

Therefore, the upstream segment is capital-intensive, occurs in regions in the world where there are crude oil or natural gas resources, and includes the analyses with technological equipment before the discovery of the crude oil, and the drilling of the wells. In 2012, approximately 100 countries drilled for crude oil, with the top five drilling countries of Saudi Arabia, Russia, US, China, and Canada, contributing nearly half of global production (Melton et al 2015:2). As of 2020, data reviewed by Investopedia (2021) revealed that the same countries were again classified as the top crude oil producing countries in the world.

In 2019, Total South Africa (Pty) Ltd discovered gas under the sea in Mossel Bay, South Africa, an example of analysing with technological equipment before the discovery of the gas and drilling of the wells (Business Tech 2019). With the discovery of gas, it can therefore be anticipated that in the coming years, there will be upstream activities in South Africa which will include drilling of the well. The section below will discuss the transportation of crude oil from the wells to the refineries, an activity in the midstream segment.

2.4.2 The midstream segment

The midstream segment links the production of crude oil to the processing facilities (World Bank 2010:7), meaning the upstream and downstream segments, respectively, of the petroleum value chain. In the midstream segment, the main activities are related to transporting the crude oil (Holle et al 2019:3) that was produced in the upstream segment. In the midstream segment, infrastructure for transportation, such as pipelines, access to roads, rail and ports, as well as storage facilities are critical. Transportation options for crude oil are diverse and flexible, allowing crude to be redirected toward other markets if required (Holle et al 2019:3). On a daily basis, millions of barrels of crude oil are transported across the globe through the different modes of transport to crude storage facilities or refineries (Haderer & Austria 2013:42).

Nearly 6% of the crude oil processed by US refineries are purchased from local companies and transported by barge, truck, and rail (Levine, Taylor, Aurhur & Tolleth

2014:16). Although the use of these other modes of oil transport is growing, most crude oil is still transported via pipelines and ocean-going tankers to US refineries (Levine et al 2014:8). Saudi Aramco has an interconnected overseas transportation, storage, and supply facility in Saudi Arabia for crude oil, refined petroleum products, gas, and liquids (Shammas 2000:43-45). They have the world's largest shipping fleet of tankers and vast domestic and foreign oil storage facilities, including facilities in Europe, the US, the Caribbean and the Asian / Pacific basin (Shammas 2000:45).

In Africa, there are multiple modes of transport for crude oil. Nigeria transports crude oil via a pipeline network, sea, road and rail wagons (Obasanjo 2013:15), while South Africa imports most of its crude oil via ocean-going tankers and puts it into the pipeline for inland refineries such as NATREF (SAPIA 2014:15). Therefore, the primary mode of transporting crude oil in South Africa from the sea to the inland refinery in Sasolburg is by pipeline. The midstream segment is therefore the link between the upstream and downstream segments and transports crude oil produced to the refineries, to be further processed in the downstream segment.

2.4.3 The downstream segment

The downstream segment, the last part of the petroleum industry value chain, includes the refining of crude oil into different petroleum products (Haderer & Austria 2013:36). This segment also includes the marketing and distribution of the refined petroleum products from refineries to terminals situated close to the markets, from where the products are transported via road to retail outlets (Canadian Fuels Association 2013:10). The section that follows will discuss the refining activities of the downstream segment in more depth.

2.5 CRUDE OIL REFINERIES

The crude oil refinery is part of the downstream segment and transforms crude oil into multiple petroleum products (Vaillancourt 2014:2). The refinery process divides the crude oil into fractions to be blended to precise specifications (Canadian Fuels Association 2013:1). Although most refineries process crude oil, in South Africa, there are coal, gas, and crude oil refineries which produce petroleum products (SAPIA 2015:19). The subsections that follow will discuss the different types and sizes of crude oil refineries.

2.5.1 Types and sizes of crude oil refineries

Refineries are often classified into five categories or types of refineries according to their complexity (O'Driscoll 2016:35). A summary explaining the five types of refineries as defined by Andrews et al (2014:2) is as follows:

- Basic or topping refineries are a basic type of refinery, which isolate the components of crude oil into different refined petroleum products through distillation, but typically cannot produce petrol.
- Hydro skimming refineries have a naphtha reformer and a topping facility which conduct the straightforward separation process. These reformers produce hydrogen, which can be "skimmed off" for use in desulphurisation units, such as hydrotreaters. This refinery is slightly more complex than the basic refinery and produces petrol and excess fuel that is often in low demand.
- Cracking refineries have catalytic cracking units, fluid catalytic cracking, or a hydrocracker. In addition, there is an alkylation plant, which is used to produce products of higher value, such as petrol or diesel.
- Coking refineries perform similar to cracking refineries, but also have cooker units, which transform heavy vacuum residuals into high-quality products such as petrol and diesel.
- A full-conversion (or complex) refinery is an oil refinery connected to a petrochemical plant. It has steam cracker and coking refinery capabilities. The steam cracker is used to manufacture ethylene and propylene.

The types of refineries discussed above range from the basic refinery, which cannot produce petrol, to a full-conversion refinery, which produces all the petroleum products and raw materials used in the production of plastic. It is evident that each type of refinery has distinct capabilities and that a range of advanced processes is used.

In addition to the types of crude oil refineries, they are also of different sizes. The size of the refinery is determined by the quantity of crude processed, usually indicated in barrels processed daily, or tonnes processed annually (O'Driscoll 2016:35). The average size of refineries has been steadily rising over time following the changes in economies of scale (O'Driscoll 2016:35). In South Africa, the largest crude oil refinery, SAPREF, processes between 180 000 and 190 000 crude oil barrels daily (Ratshomo & Nembahe 2018:12). Therefore, when looking at refineries, the size and types may be taken into account to determine which crude oil and how much crude oil a refinery processes to produce the specific required product mix.

In the US, Asia, Middle East, and South America most refineries are full-conversion, with upgrading units, while in Europe and Japan most refineries are hydro skimming and full-conversion (Vaillancourt 2014:1). In Africa, most refineries can be classified as topping refineries (Mbendi 2018). The refineries in Nigeria are however mainly complex conversion with the Warri refinery having a fluid catalytic cracking unit (DPR 2020).

In South Africa there are four reasonably sized crude oil refineries with cracking facilities (Bird, Von Gruenewaldt & Burger 2017:2), therefore they can produce high value products such as petrol and diesel. However, one refinery, NATREF has both hydrocracking and catalytic cracking units (Kojima 2013:26) with Bird et al (2017:2) stating that NATREF is a full-conversion refinery. This therefore implies that NATREF is not only able to produce high value petroleum products, but also the raw materials used in the production of plastic. Furthermore, as much as NATREF is medium-sized, it has advanced technology, which makes it easy to refine heavy crude oil effectively (Ratshomo & Nembahe 2018:11). In South Africa, NATREF is therefore an advanced refinery and SAPREF has the largest capacity to refine more high value petroleum products such as diesel and petrol. The subsection below will discuss the refinery process of dividing crude oil into petroleum products.

2.5.2 Refinery process of dividing crude oil

In refineries there are three phases of processing crude oil into petroleum products, namely separation, conversion, and treatment (Canadian Fuels Association 2013:2; Do 2014:18). The three phases are defined below:

- Separation is the phase where crude oil is heated to varying temperatures. As the temperature rises, the crude oil is separated into different parts. This is completed in the distillation towers.
- Conversion is the phase where the conversion method known as cracking is used, involving the use of high temperatures and pressure to 'crack' or break heavy hydrocarbon molecules down into smaller molecules, as well as chemical catalysts.
- Treatment is the final phase, which involves treating the components produced to improve their quality, by mixing them with additional elements to refine the final petroleum products.

The crude oil refining process therefore starts with the separation phase, followed by the conversion phase and ends with the treatment phase. The flow diagram in Figure 2.2 shows the refining processing flows and the discussion identifies the three phases discussed above.

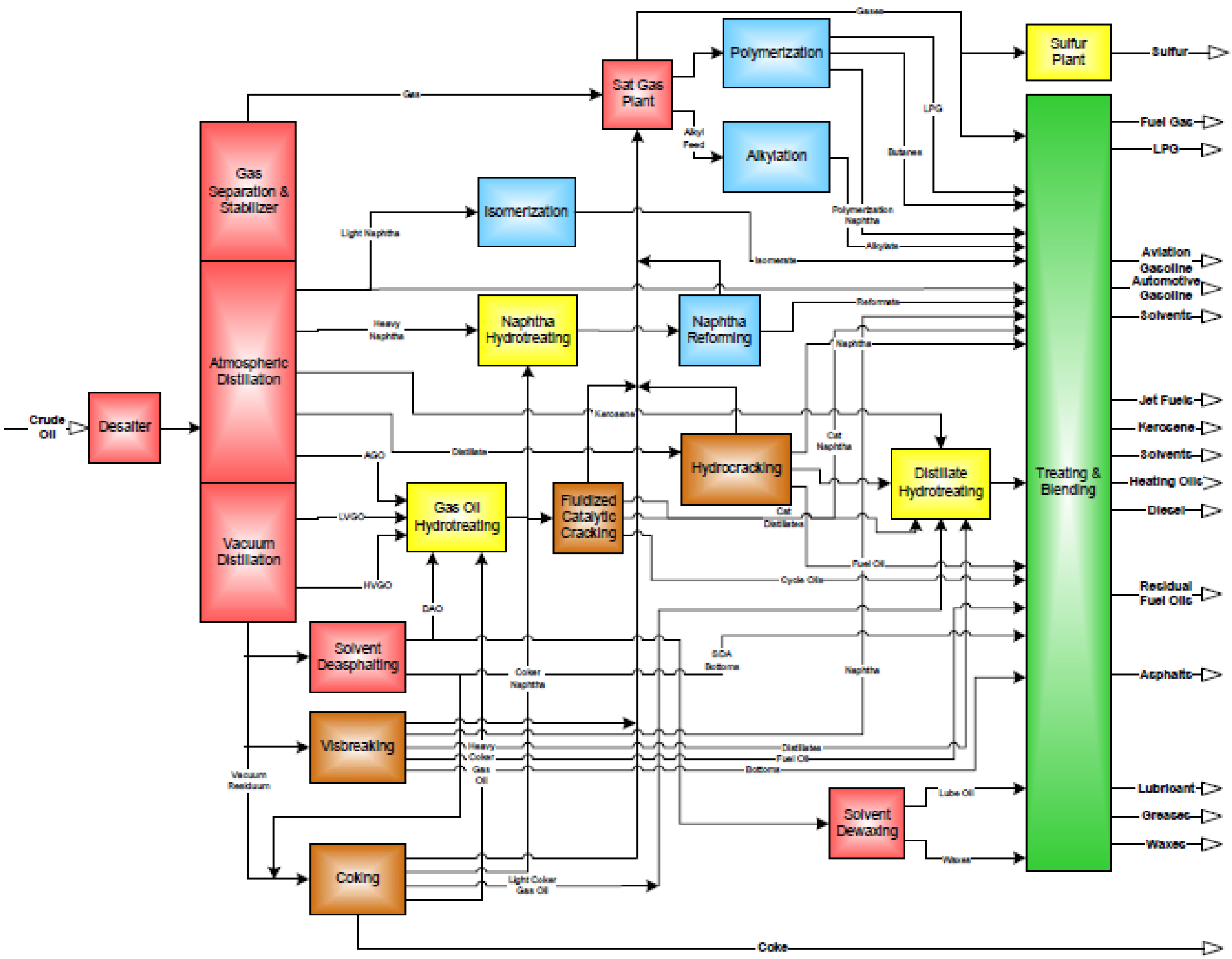


Figure 2.2: Crude oil refinery flow diagram

Source: Jechura (2018:34)

The left-hand side of Figure 2.2 indicates the point at which the crude oil is added to the crude oil refinery production process. The red colour shows the separation phase, the middle flow shows the conversion phase, while the green colour shows the treatment phase discussed above. As reflected on the far-right hand side, multiple products of output from different flows are produced. The next subsection will discuss the different types of crude oil that form the input into a refinery production process.

2.5.3 Types of crude oil

In the crude market, there are more than 150 different types of crude oil (Canadian Fuels Association 2013:6; Do 2014:30). Crude oil markets use the quality to identify the type of crude oil, classifying it into light, heavy, sour, and sweet crude oils (Haderer & Austria 2013:19; Do 2014:30). Refineries can refine either lighter or heavier grades of crude oil (Canadian Fuels Association 2013:6). Junge (2010:13) states that crude oil with a higher quantity of lighter hydrocarbons is classified as light crude oil, while heavy crude oil has a higher proportion of heavier compounds. The crude oil with low sulphur is classified as sweet crude oil, while sour crude oil has high sulphur (Junge 2010:13). The cost of light crude oil is higher as it produces higher value petroleum products such as petrol and diesel in comparison to heavy crude oil. While the sweet type has a high cost it has fewer environmental challenges compared to sour crude oil (O'Driscoll 2016:25). Therefore, the sweet and light crude oil costs are higher than that of sour and heavy crude oil.

Some common types of crude oil are used as the basis to determine the value of other crude oil, based on the following four common references (Haderer & Austria 2013:19):

- Brent blend is used as a reference for a combination of numerous crude oils from areas in the North Sea region, situated above Germany and the United Kingdom. Brent blend is commonly referred to as Brent crude oil or Brent ice.
- Dubai-Oman is used as a reference for the Middle East sour crude oil, which is moved to the Asia-Pacific region.
- Tapis is used as a reference for East Asia light oil from Malaysia.
- West Texas Intermediate (WTI) is used as a reference for American high quality sweet, light oil.

The two most important references for crude oil are WTI and Brent crude oil (Levine et al 2014:36). The price of Brent crude oil is used globally as a price reference for more than 60% of the world's crude oils from different markets (Canadian Fuels Association 2013:13). Saudi Arabia, Nigeria and Angola are the main countries which South Africa imports its crude oil from (Ratshomo & Nembahe 2018:10), hence, it mainly uses Brent as a reference for its crude oil.

There are several qualities of crude oils that make them preferred by a refinery (Levine et al 2014:13). Heavy crude oils are less expensive, but the refining process is more expensive as greater processing costs are required (Canadian Fuels Association 2013:6). If the refinery's configuration ability allows for the conversion of cheaper heavy crude oil, profits will be higher because higher-value product mixes can be realised (Canadian Fuels Association 2013:6). While a refinery can process various mixtures of crude oil, the different crude oil types used determine the crude oil value and may be used to optimise the output of the refined petroleum product. The following section will discuss the determination of the output of the refinery.

2.5.4 Determining the product mix of the refinery

Planning the refinery production mix is performed using complex mathematical calculations, therefore, this activity is highly controlled and monitored (Canadian Fuels Association 2013:11). Production planning is an important activity as it determines the refinery utilisation and profitability (Joly 2012:371). To achieve accurate planning, a refinery may use different mathematical models, for example linear programming for blending, with the model estimating the final petroleum products mix required to be produced (Fahim, Al-Sahhaf & Elkilani 2010:255). Drury (2018:695) defines linear programming as "a powerful mathematical technique that can be applied to the problem of rationing limited facilities and resources among many alternative uses in such a way that the optimum benefits can be derived from their utilisation".

During the planning process, the employees responsible for refinery production choose the type of crude oils that can be processed and determine the different mix of petroleum products that will be produced (Canadian Fuels Association 2013:11). Hence, in the planning process, the refinery chooses the right crude oil that will optimise the refinery capacity, by producing a certain petroleum product mix when the margins are high

(Canadian Fuels Association 2013:4). The refinery margin is the variance between the refinery's aggregate price for the refined products and the price of the crude oil processed in the refinery. Figure 2.3 is an interpretation of the different petroleum products that can be produced from 42 barrels of crude oil. The US EIA (2019) states that 42 barrels of crude oil may produce 45 US gallons of petroleum products. The US uses the imperial system of measurement (Britannica 2020), whereas South Africa uses the metric system (Ancestors 2019), with 45 US gallons being approximately 170 litres (Unitconverters 2020), therefore 1 gallon is roughly 4 litres.

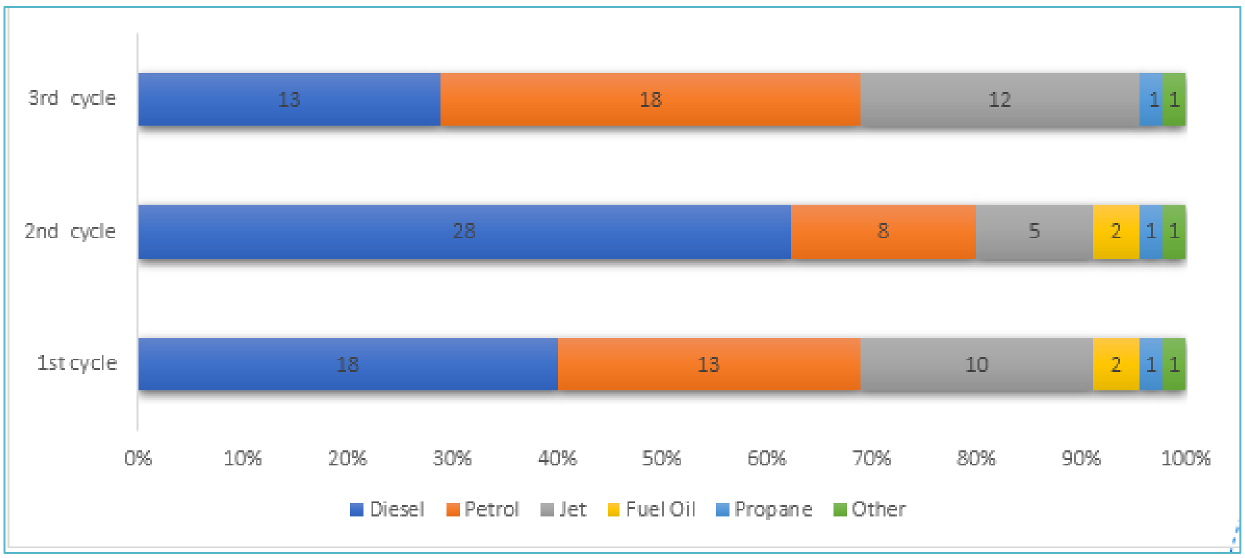


Figure 2.3: Planning for output of petroleum products in gallons and percentages

Source: Own interpretation –Canadian Fuels Association (2013:4-6), US EIA (2020) & Vaillancourt (2014:10)

The main sources of data in Figure 2.3 are the US and Canada, which mainly use gallons to measure the petroleum product, thus the analysis of Figure 2.3 is based on gallons. Figure 2.3 shows the changes in the production of petroleum product outputs from different production cycles, based on 45 US gallons. In the first cycle of the total production, there is 40% (18 gallons) diesel, 30% (13 gallons) petrol, 20% (10 gallons) jet fuel and 10% (3 gallons) other products. However, the outputs in the second cycle differ considerably, with 65% (28 gallons) diesel, 15% (8 gallons) petrol and 30% (9 gallons) other products. In the third cycle, there is 25% (13 gallons) diesel, 45% (18 gallons) petrol, 25% (12 gallons) jet fuel and 5% (2 gallons) other products. When a change in market demand occurs, the refinery is geared to change the production plan to the specific petroleum product mix, for example, if the demand for diesel relative to petrol increases as a result of an increase in diesel vehicles manufactured (Canadian Fuels Association 2013:4).

The ability of the refinery to adapt its production product mix to accommodate demand changes influences its profitability (Canadian Fuels Association 2013:4). While refineries may choose the petroleum product mix from one barrel of crude oil, there is a standard of nine different petroleum products that may be produced, as illustrated in Figure 2.4.

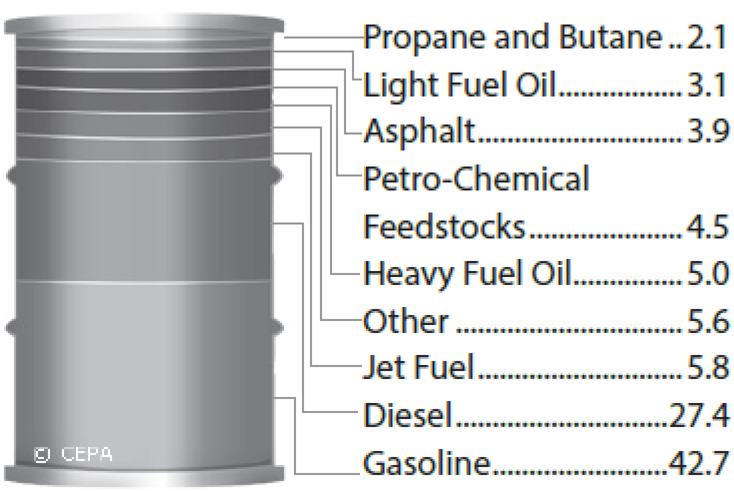


Figure 2.4: Different products that can be produced from one barrel of crude oil, in percentage
Source: Canadian Fuels Association (2013:6)

Of the nine different petroleum products indicated, each with a related percentage in Figure 2.4, the last three, namely jet fuel, diesel, and petrol (gasoline), account for 75,9% of the products produced. These nine petroleum products may be classified into four groups of refined petroleum products.

The four groups of refined petroleum products that can be produced as per US Environmental Protection Agency (2012:2-9) are as follows:

- Fuels: Finished petroleum products that can release energy. These are used for machines or vehicles such as motor vehicles, jets, and ships. Primary petroleum fuel products include petrol, diesel, jet fuel and residual fuel oil.
- Finished nonfuel products: These products do not fuel machines or equipment and mainly include asphalt, lubricants and solvents.
- Feedstock: Multiple products mainly intended for use as petrochemical feedstocks in the production of plastics, synthetic fibres, synthetic rubbers and other products.
- Sulphur: Commercially used as a main commodity in fertilisers due to the relatively high demand of plants for fertilisers and in the production of sulphuric acid, the main industrial chemical for fertilisers.

Each of the groups of refined petroleum products are linked to products of a certain value and use. For example, fuel is linked to high value products, such as diesel and petrol, used for machines and vehicles, while sulphur is a lower value product, used in fertilisers. Most refinery operators may however choose to produce a product that has both a high value and demand, in order to cover operating costs. The following section will discuss the operating costs and margins of refineries.

2.6 INTERNATIONAL OPERATING COSTS AND MARGINS OF REFINERIES

In several companies, production profitability is calculated as the difference between the cost of production and the value of sales. To gain a competitive advantage, a company may produce a higher quality product at a low production cost by having an efficient production process.

2.6.1 Operating cost of a refinery

There are direct and indirect operating costs in a refinery, with direct costs normally directly linked to the crude oil input, while indirect costs are mainly related to the costs not directly linked to the production (Fahim et al 2010:408). Multiple factors impact the indirect cost of a refinery, such as the size and complexity of the refinery, utilisation rate, salaries of the employees, and environmental regulations. For example, a large refinery will have a high salary cost, as it may employ a large number of employees, while a small refinery will have a lower salary cost with fewer employees (Vaillancourt 2014:7).

2.6.1.1 Direct cost of a refinery

Crude oil is the main direct cost in a refinery (Chesnes 2015:37), representing 80% of the processing cost (Stratiev, Dinkov, Nikolaev & Stanulov 2010:1). Crude oil costs are set by international markets (Chesnes 2015:37), and therefore change multiple times with international, regional, or local market prices (Canadian Fuels Association 2013:3).

The type of crude oil that produces a high percentage of high value refined petroleum products and which may be used by multiple refineries worldwide, costs more than the crude oil that produces a high percentage of low value refined products, which can be used by fewer refineries in the world (Holle et al 2019:6). In the production process, there are additional chemicals and additives, with their costs forming part of processing cost, as well as the cost of fuel used in the production process, which is considered to be part of the direct cost (Fahim et al 2010:405). The direct cost is normally incurred per unit, and it may therefore be linked to each processing flow. Direct cost therefore forms part of the processing cost of production because it is a fixed amount per unit. The total direct cost therefore increases or decreases in relation to an increase or decrease in processing flow or production volume.

2.6.1.2 Indirect cost of the refinery

Refineries are capital intensive considering the equipment and machines used to refine crude oil (Melton et al 2015:2). Capital-intensive activities have high indirect operating costs, as a high level of fixed assets are used in the production process (Cai 2018:74-75). The total indirect cost does not change with the production process activities (Fahim et al 2010:405), implying that when production volume increases, the indirect cost per unit of production will decrease. Therefore, when production volume decreases, the indirect cost per unit will increase. Examples of main indirect costs for a refinery are salaries, maintenance cost, depreciation (Fahim et al 2010:405) and general services such as utilities that include cooling water, heating steams and electricity (Cruz, Iribarren & Dufour 2019:7). Refineries focus more on the indirect cost as they can control those costs, even though they are a small percentage of total costs (Chesnes 2015:12). The indirect cost may therefore not always be directly linked to the specific processing flow or production volume as they are payable even if the refinery is not processing any crude oil into petroleum products, for example, utilities and office space.

2.6.2 The refinery margins

The profitability of a refinery is normally determined by the supply of crude oil and the demand for refined products (Stratiev et al 2010:1). As previously discussed, the market prices of both crude oil and petroleum products are volatile as a result of being linked to international markets (O’Driscoll 2016:68). A refinery may have high profit margins when crude oil prices are low, and there is a high demand for refined petroleum (Chesnes 2015:12). Therefore, when the crude oil price is high, and the demand for refined products is unchanged, a refinery may have a low profit margin.

The economic performance of a refinery is measured by the crack spread, which is defined as the difference between the price of the refined products and the cost of crude oil (Chesnes 2015:12). Both the product price and the purchase cost of crude oil must be weighted because they reflect the multiple petroleum products produced, the refinery product mix, as well as the multiple types of crude oils used as refinery inputs (Pirog 2007:5). The crack spread is used to determine the two high value petroleum products to be refined from one barrel of crude oil, namely diesel and petrol (Chesnes 2015:12). The crack spread is calculated based on the refined petroleum product price, less the cost of crude processed, with the main crack spread being determined with diesel and petrol (Do 2014:28). The crack spread is often used to replace the profitability of converting a barrel of crude oil into high-value petroleum products, and if the price of refined petroleum products falls below that of crude oil, the crack spread becomes negative (Chesnes 2015:2). Therefore, the term crack spread, which is similar to a profit margin, is used in the petroleum industry when applied to petrol and diesel to measure its profitability.

The ratio of how much crude oil is extracted into different refined petroleum products is a significant measure of the crack spread, since each type of crude oil produces a different petroleum product, and each petroleum product has a specific price (Do 2014:28). Therefore, the crack spread may be used to determine the type of crude oil to be used by a refinery and which petroleum products should be produced. The 3-2-1 crack spread defines a multiple product crack spread, which means that three barrels of crude oil can be processed or refined into two barrels of petrol and one barrel of diesel (Fahim et al 2010:409). The crack spread is mainly defined by the type of refinery, with other significant influences including crude oil type processed, location, crude transportation, and general efficiency which includes product mix produced (Do 2014:29). Hence, crack spread is used as a primary indicator to determine the refinery product mix to be produced and crude oil type to be processed taking into consideration the type and size of the refinery.

As much as there are operating costs of the refinery, the refinery profits margins are therefore calculated based on the crack spread, which is linked to the international market prices of the crude oil used, versus the price of the refined petroleum products produced. The following section will discuss the regulated petroleum product prices in South Africa that are calculated using the deemed cost which is based on BFP and the refinery margins.

2.7 THE SOUTH AFRICAN DEEMED PETROLEUM PRODUCT COST AND MARGINS IN THE CRUDE OIL REFINERIES

South Africa is a small player and a price taker in the global petroleum market, because it imports crude oil due to its small crude oil reserves and because South African refineries have a 0.7 MMbbl/d crude oil capacity compared to the world refineries' capacity in 2020 of 101 MMbbl/d (bp Statistical Review of World Energy 2021:31). South Africa thus relies on the international market when it comes to petroleum price indications. Therefore, the South African petroleum price for the regulated product is based on the international price. The following section will discuss the deemed petroleum product cost in South Africa.

2.7.1 The deemed petroleum product cost in South Africa

The product cost of selected petroleum products, such as diesel and petrol, is regulated in South Africa. The DOE calculates the regulated price for regulated petroleum products (DOE 2018:3). According to the DOE (2018:3), regulated fuel prices used to be based on the assumption of import parity prices known as the In-Bond-Landed-Costs (IBLC) methodology. The IBLC was used before the development of the refining industry in South Africa in the 1990s.

The IBLC was used to determine the import prices of fuels, and consists of the following:

- free-on-Board (FOB) based on the weighted prices for the refining centres, in the Mediterranean area, the Arab Gulf and Singapore, prices for refined petroleum products;
- insurance at a tariff set internationally;
- freight based on the published Worldscale Association transport rates, plus the weighted monthly rate from the place where the product is purchased to South African import terminals;
- ocean leakage which relates to the ocean losses on the imported product;
- demurrage cost which relates to the cost of the cargo standing time before the product is discharged;

- stock-holding costs; and
- stock financing costs.

Before 2003, the IBLC was used in South Africa to determine the coastal refinery gate prices (Mondliwa & Roberts 2014:553). A premium was added to the coast price for inland refineries to determine the inland refinery gate price (Mondliwa & Roberts 2014:553).

As the substitute to the IBLC, the BFP was announced in 2003 primarily as a formula to determine the prices of regulated petroleum products refined by South African refineries (SAPIA 2022). The BFP is referenced to international markets; with petrol and paraffin illumination currently referenced in the Mediterranean region (50%) and Singapore (50%) and diesel referenced to the Mediterranean region (50%) and the Arab Gulf (50%) (SAPIA 2022). Therefore, the change from IBLC to BFP differs in the FOB calculation where the IBLC was based on the weighted average prices of international refining centres, while the BFP mainly focuses on the refining centres from which the product is produced. Figure 2.5 is a map indicating the reference areas of the BFP.

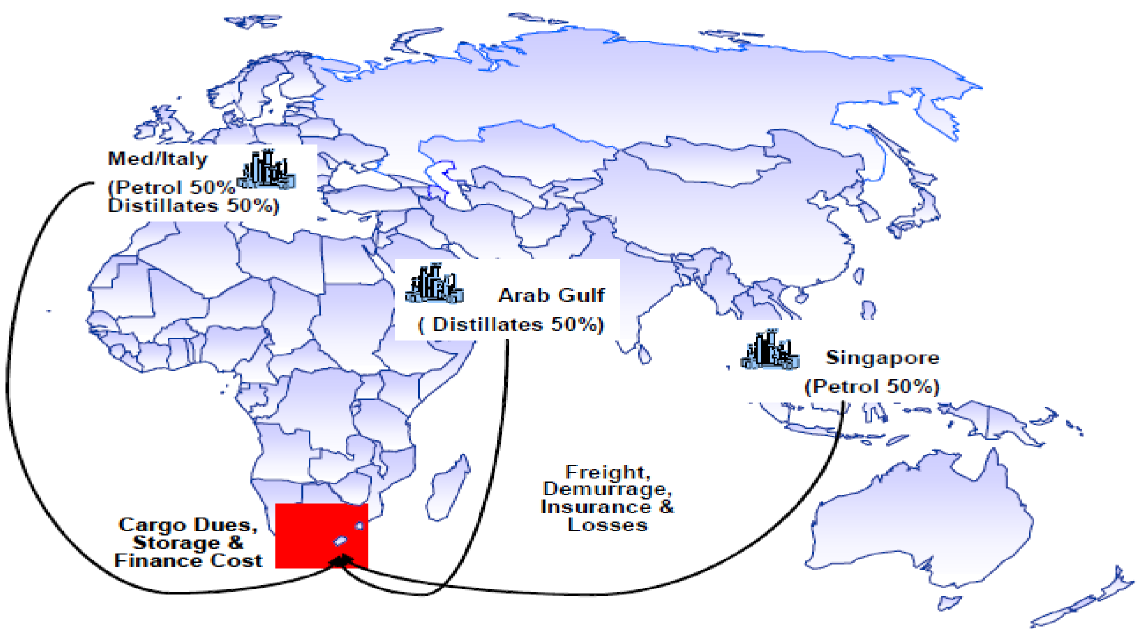


Figure 2.5: Map for different reference markets used to determine the BFP
Source: DOE (2008:12)

Figure 2.5 shows the various markets which are used to calculate the BFP for different products, namely petrol, and distillates, also known as diesel. As indicated in the IBLC variables, the FOB represents the price of petroleum products quoted daily by the refining locations shown in Figure 2.5. It is used to refer to international petroleum products in the South African fuel price media statements. As shown in Figure 2.5, product cost relates to the FOB in the Mediterranean, Singapore, and Arab Gulf refineries. Subsequently, the direct costs relating to transportation of petroleum products to South African ports, as well as the estimated cost of storage and cost of financing the stock values are added to calculate the BFP.

The actual operating costs of South African refineries, including indirect costs, are not considered in the BFP calculation of the petroleum products; hence the refineries do not have the visibility of an accurate product cost. South African refineries use the import parity based on the BFP calculation, as described above, as the base for the product cost, and that cost is deemed the product cost which is used as the transfer price from refineries to marketing. This means the full value chain may have over- or under-stated the cost of the regulated petroleum product and does not have an accurate view of the actual product cost of refining petroleum products from local refineries. The section below will discuss the South African refinery margins.

2.7.2 South African refinery margins

The profitability of a South African refinery is directly linked to the international refining margins, known as the crack spread. The crack spread is linked to the crude oil price and petroleum products' price in the international market. The crude oil price fluctuation affects the relationship between refining margins and the BFP (Rustomjee et al 2007:66-67). As explained in section 2.7.1, the South African BFP is linked to the Singapore, Arab Gulf and Mediterranean market prices and their market prices are calculated from the international crude oil price and refinery margins (Purvin & Gertz Inc. 2008:282-287). Therefore, the BFP is linked to the international crude oil prices and refining margins, hence an increase in crude oil price and refinery margins cause an increase in the BFP, which allows the refinery to cover its operation cost (Wabiri & Amusa 2011:1). This means that the BFP is linked to international markets and does not take into account the actual production cost of petroleum products from local refineries.

One of the objectives of the BFP is to ensure that a refinery earns refining margins to cover its operating cost and becomes profitable, thus even though the international refining margins change on a daily basis, the BFP changes once a month (DOE 2008:1). The impact of the daily variations in crude oil prices and refining margins are absorbed by the refinery (Du Pont 2004:10), which may lead to an imbalance between the BFP and actual cost. Considering a situation whereby the crude oil price increases by USD 2$/barrel at the last day after the finalisation of the BFP, the BFP will be calculated on a low crude oil price, while purchases of crude oil were at a higher price, which will result in a lower BFP or even a negative refining margin.

From Du Pont's study of NATREF's performance in 2004, the South African refining margin is defined as the gross margin, which is the petroleum product at BFP less crude oil cost less cash costs. The cash costs are indirect costs, for example, insurance, maintenance, labour, energy, catalyst, hydrogen, and utilities. Therefore, the margin of the refinery is calculated holistically where the indirect cost is shown as the total value or allocated using a volume ratio to determine the margin of each regulated petroleum product. The South African crude oil refineries use the international refining margins which are factored into the BFP, direct and indirect cost, to determine their profitability. The indirect cost of the crude oil refinery is currently allocated based on volume produced of the final refined petroleum product to determine the production cost of each unit produced, and therefore the refineries do not use ABC.

2.8 SUMMARY

The establishment of the oil industry began in 1846, when a Canadian geologist discovered that oil could be refined for the manufacture of petroleum products. Between

1855 and 1950 crude oil was discovered in different regions in the world. Primitive oil production started in Russia in 1745 while oil was discovered in the US oil in 1855, in various European countries between 1853 and 1860, and in African countries between 1908 and 1950. With the discovery of oil, as early as 1860, mechanical drilling rigs were used, extending discoveries and commercial oil production from 1908 to 1952 in various countries including Britain, Saudi Arabia, Nigeria, and Algeria.

With the establishment of crude oil wells and the realisation of the importance of petroleum products refined from crude oil, different countries started to construct refineries. The first refinery was commissioned as early as 1840 in Romania. The US built its first refinery in 1865, and Saudi Arabia's oldest refinery started operating in 1945. In Africa, the first refineries were built in 1954 in South Africa and Algeria. In the different regions, multiple small refineries were initially built, with many subsequently closed due to a trend of having fewer, larger refineries.

The petroleum industry is one of the growing industries in the world as well as one of the most productive and dynamic industries. The industry has contributed positively and significantly to the GDP of multiple countries. The COVID-19 pandemic has caused disruption of the industry growth due to a production decrease which led to the decrease in countries' GDP's.

There are three segments in the petroleum industry value chain. The upstream segment includes discovering, exploring, and drilling of crude oil and gas. The midstream segment transports the crude oil from the oil wells to the refineries, and the downstream segment includes the refining process, as well as the marketing and distribution of refined petroleum products to facilities close to the retail outlets.

There are five types of refineries, differing in process complexity and the value of petroleum products produced. The most basic refinery is the topping refinery, followed by hydro skimming, cracking, and the coking with full-conversion being the most advanced refinery. The first two refineries mainly produce petrol and low value products, while the last three produce high value products. Different countries have different types of refineries with South Africa having four reasonably sized crude oil refineries comprising two types of crude oil refineries, one being a full-conversion refinery and the rest being cracking refineries. Regardless of the type, refineries have three phases of refining crude oil to petroleum products, namely separation, conversion, and treatment.

About 150 different types of crude oil exist, classified based on their quality as sweet, sour, light or heavy crude oil depending on their hydrocarbons. However, to determine the value of crude oil, four references are used, namely Brent, Dubai-Oman, Tapis and WTI. The type of crude oil to be used in the production process is determined in the planning process, because the refinery may use different crude types to determine a certain output of petroleum products mix, as well as the process that it uses to optimise the capacity and output of the refinery.

The operating costs of the refinery may be classified as either direct or indirect costs. Direct costs are linked to the refinery production process and are normally incurred as a unit of the production units hence it increases or decreases with the volume produced. Crude oil is the main direct cost in the production process to refine petroleum products; in addition there are chemicals and additives as well as the cost of fuel used in the production process. While the indirect costs may not be directly linked to the processing flow, they are incurred even if the refinery is not operational. The refinery is capital intensive therefore there are some indirect costs which are linked to the fixed assets such as depreciation and maintenance.

The margin of the refinery is determined by the crack spread based mainly on the two high value petroleum products, diesel and petrol. A major determinant of a crack spread is the ratio of the crude oil refined into different petroleum products considering the value and type of crude oil used. Hence, during the production planning process, refineries determine the type of crude oils that can be processed, and the different mix of petroleum products that will be refined. The flexibility of the refinery is important to meet the market demand, as the optimisation of the refinery is taken into account during the planning process.

As much as refineries use the crack spread, there are actual operating costs which can be classified as indirect and direct costs. The direct cost can be linked to the specific production process, while indirect cost cannot be. For the refinery to have an accurate product cost for each petroleum product, the indirect cost should be allocated accurately to each refined petroleum product. The South African refinery margins are based on international margins. The BFP is linked to international crude oil prices and refinery margins, hence the volatility of the crude oil price and refinery margins before or after announcing the BFP each month, is absorbed by the refineries.

South African refineries currently use the deemed cost which is based on the BFP to determine the refinery selling price for some petroleum products. Prior to the adoption of the BFP, the IBLC was used to calculate the refinery gate prices of petroleum products. The BFP is based on the FOB cost of refining centres in the Mediterranean area, Arab Gulf and Singapore, plus the cost associated with transporting the product to South African ports. Therefore, the BFP does not include the actual operating cost of refineries, hence, refineries do not have the advantage of accurate petroleum product cost.

The ABC represents a costing system the South African crude oil refinery could adopt to allocate indirect costs more accurately for selected regulated petroleum products, which will then allow for improved subsequent optimal petroleum product mix decisions. The following chapter will therefore discuss ABC.

CHAPTER 3: AN ACTIVITY-BASED COSTING SYSTEM IN SOUTH AFRICAN REFINERIES

3.1 INTRODUCTION

An overview of the South African petroleum industry was provided in Chapter 2 with the focus on the industry background, contribution to the country's economy, and its value chain activities. Chapter 2 also included the process of refining petroleum products, how to calculate its margins, and how the refinery petroleum product cost is calculated. Then, it summarised how petroleum product cost calculations in South African refineries are based on a deemed cost, the BFP.

The purpose of this chapter is firstly to investigate concepts generally associated with an ABC system, considering the ABC through the lens of optimisation theory as set out in objective 2 of the research study. Secondly, based on the literature survey, a preliminary discussion of adopting ABC in crude oil refineries in South Africa through the lens of optimisation theory, will be executed.

Chapter 3 will discuss the need for more accurate and relevant costing information based on two costing systems, namely the TC and ABC systems. It will also explain how ABC was developed due to the shortcomings of the TC, followed by the advantages and disadvantages of ABC. Thereafter, the factors to be considered before implementing ABC are put forward followed by the steps to successfully implement ABC. Key success points for implementing ABC are discussed. This chapter will also include various studies demonstrating the benefits of adopting ABC and a discussion of ABC through the lens of optimisation theory.

3.2 THE NEED FOR MORE ACCURATE AND RELEVANT COST INFORMATION

Costs are not calculated in a vacuum, which is one of the reasons most organisations use cost systems to calculate and gather costing information (Labro 2019:5). Costs are calculated for use in the organisations by managers for stock valuation, costing-related decision making and performance evaluation (Labro 2019:5). Drury (2018:267) revealed that costing systems vary based on their level of sophistication and which cost are allocated to products. In addition, Bvumbi (2017:13) noted that managers require a timely cost management system that provides high-quality information to assist in decision-making. Therefore it is important for managers to know the cost management systems available which may provide more accurate and relevant cost information. The following section provides an overview of costing systems.

3.2.1 Costing systems to allocate indirect cost

The objective of a management and cost accounting system is to allocate costs to products for purposes of reporting to the management or shareholders and to provide managers with the relevant cost data for decision making (Drury 2018:16). Product costing analysis enables companies to better understand their cost structure and cost information that is important for optimal operational and strategic decision making (Aldukhil 2012:52). For example, cost data is used to determine the selling price, measure the profitability of the product, determine different products to be produced, and is used for planning and decision making (Aldukhil 2012:1). Therefore it is crucial for the organisation to have a costing system that is determined by more accurate and relevant cost data.

Management cost accounting recognises, computes and assigns direct and indirect costs to a specific product; it also stresses the importance of complete identification of direct and indirect costs (Lutilsky & Dragija 2012:38). To appreciate how and why costing systems are not the same, it is important to understand the different aspects of each costing system (Reynolds 2013:14).

This chapter will focus on two costing systems which are ABC and TC. The ABC is a costing system that classifies and assigns costs to indirect cost activities and then allocates those costs to products (Drury 2018:257). On the other hand, TC is a costing system that allocates indirect cost to products based on volume-based cost drivers such as the volume of production, direct labour hours consumed or machine hours used (Drury 2018:260). Therefore, the main difference between TC and ABC is the allocation of indirect cost. Furthermore, Reynolds (2013:14) adds that TC and ABC have the same total value of direct cost and indirect cost, and the difference between the two systems is the allocation of indirect cost to specific product cost. The following section will discuss the TC system.

3.2.2 Traditional costing

The TC system allocates indirect costs from indirect cost centres to products based on the production volumes or hours incurred in the production process (Drury 2018:188-189; Wen-Zheng & Yazid-Abu 2019:1). However, the total cost spends on indirect costs by a given type of cost over a certain period is often not properly allocated to products by hours or volumes produced (Ray 2012:71).

The TC system uses arbitrary allocation, which hides the source of savings as costs are included in a pool of indirect cost (Madwe 2017:13), and it does not recognise that there are different levels of activities in the production process (Aldukhil 2012:17). Therefore, product costs calculated from the TC system may not reflect the actual cost of producing the specific product due to the arbitrary allocation based on volume or hours.

In the TC system, the indirect cost allocation rate may be calculated based on budgeted production volume (Madwe 2017:12). The volume-based allocation causes the rate to vary according to the anticipated volume demand. For example, the indirect cost rates become higher if the budgeted volumes are lower, while the indirect cost rate will be lower when the budgeted volumes are high. An indirect cost allocation rate based on production volumes, will lead to higher indirect costs being allocated to high-volume products in comparison with low-volume products, which will lead to a higher indirect cost allocated to the high-volume product compared to the low-volume product (Aldukhil 2012:19). Therefore, a product with low volume will be allocated lower indirect costs which may lead to the product cost being understated. This means the product cost for the specific product calculated from the TC system may not be accurate and relevant due to cost subsidisation from an arbitrary allocation of indirect cost. The following section provides more information on the background and concepts of the ABC system.

3.3 ABC BACKGROUND AND CONCEPTS

Having established the need for a more accurate and relevant costing system, this subsection will provide a more detailed background of the ABC system. Different ABC concepts will briefly be explored, whereafter, the emergence of ABC from the shortcomings of TC will be contemplated.

3.3.1 Background to the ABC system

The ABC system has been used to complement the TC system since it was introduced in the 1980’s by Robin Cooper and Robert Kaplan (Yousif & Yousif 2011:10; Drury 2018:259). ABC represents an innovation in management accounting (Elhamma 2015:73) as it emerged from an increasing lack of relevance in the TC system (Salem & Mazhar 2014:44). Cooper and Kaplan (1988; 1998) described ABC as a costing system that calculates costs more precisely because the indirect cost allocation keys are designed to accurately reflect the cause-and-effect relationship in material consumption patterns at each cost pool. ABC may be used with the TC and other financial systems. Hence it should not be regarded as a substitute or threat to a company’s current systems

(Miller 2017:25). Therefore, ABC may be used to complement other company financial systems as it allocates product cost more accurately.

When the ABC system was introduced, its objective was to increase product cost accuracy (Aldukhil 2012:51). Its primary purpose is to offer a reasonable and precise indirect cost allocation, as well as a fair product profitability evaluation (Lutilsky & Dragija 2012:36). An ABC analysis enables managers to concentrate their time and resources on enhancing activities that drive the cost (Kumar & Mahto 2013:2). The ABC system corrects the challenge of product-cost subsidisation on low-volume products by high-volume products (Barton & MacArthur 2003:6; Drury 2018:260-261). Therefore, ABC emerged to improve the product cost calculation by allocating indirect cost based on activities, in order to determine more accurate product cost which may lead to relevant costing information.

3.3.2 ABC concepts

ABC is a cost accounting system that determines a company's indirect cost and allocates the cost of each activity resource to all products based on the actual usage of each activity (Chouhan, Soral & Chandra 2017:137). Therefore, it is defined as a system that allocates costs using activities linked to cost drivers (Drury 2018:267). It also emphasises the importance of identifying cost drivers, for example, the activities that cause costs to increase (Madwe 2017:9). Activities reflect the fundamental acts that can be linked together to create a process (Fountaine 2011:28), while cost drivers are those items that can be used in conjunction with the activities to distribute the real costs (Wen-Zheng & Yazid-Abu 2019:2). The ABC system measures the operational cost efficiency by identifying relevant activities and cost drivers which are then used to allocate the indirect costs to products (Ray 2012:76). Hence, it is used as a system to calculate and provide accurate information relating to product cost (Chouhan et al 2017:143).

ABC systems use various cost drivers linked to non-volume and volume-based activities to allocate indirect cost (Drury 2018:260). Non-volume cost drivers are drivers not utilised when each unit of product is produced, while volume drivers are utilised each time the unit of product is produced (Drury 2018:260). Cost drivers linked to specific activities are used to allocate costs to products in ABC (Cooper & Kaplan 1988:100; Drury 2018:264). Therefore, the main factors which influence ABC are activities and cost drivers.

ABC focuses mainly on the allocation of indirect costs, which in most companies includes the main operating costs, marketing, general and administrative costs (Ray 2012:76). Due to the increase of indirect costs in the value chain, cost management should focus on controlling production costs as well as the indirect costs (Cai 2018:28). ABC uses a two-stage allocation process, where in the first stage the indirect cost is allocated to cost pools, and in the second stage, the cost is allocated to products from cost pools based on activities and cost drivers (Chouhan et al 2017:138; Drury 2018:258). The cost pool is the sum of all resources' costs utilised by an activity to produce the specific product (Aldukhil 2012:53), and therefore it highlights the need to obtain a better understanding of all the costs added to calculate the cost pool. The following section will discuss the emergence of ABC from the shortcomings of TC.

3.3.3 Introduction of ABC from TC

ABC has emerged as a system that offers more effective indirect cost allocation than TC (Salem & Mazhar 2014:44). TC uses an arbitrary allocation method that does not reveal the source of cost reductions as the savings are concealed together in an indirect cost pool (Madwe 2017:13). Furthermore, TC does not reflect the reality that operations are carried out at various levels (Aldukhil 2012:17). Hence, TC is slowly becoming less relevant in the current global competitive business environment, which has high levels of indirect cost (Hajjawi 2017:85). The introduction of ABC therefore emerged from the shortcomings of TC, which is the arbitrary allocation of indirect cost. ABC emerged as a system that recognises that most indirect costs do not change with the amount of production output (Drury 2018:259), but rather change with the activities based on cost drivers. For this reason, it is important to understand the cost drivers that cause indirect costs to change and the activities that incur costs. A comparison between the indirect cost allocation in a TC system and an ABC system is presented in Figure 3.1.

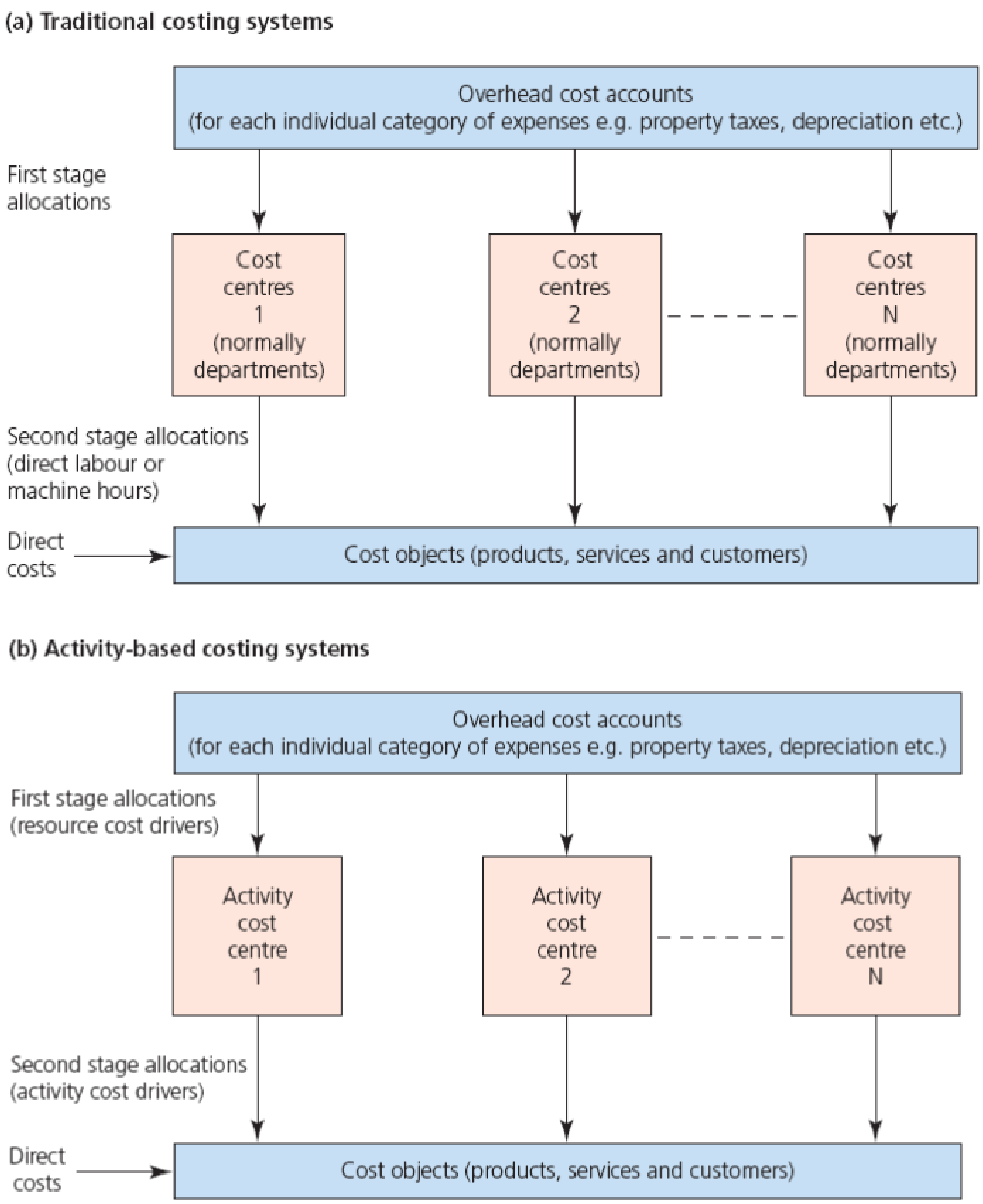


Figure 3.1: Allocation of indirect cost: TC versus ABC
Source: Drury (2018:258)

Figure 3.1 demonstrates the first and second stages of allocating indirect costs under TC and ABC. In the first stage, ABC allocates indirect costs within an activity centre to the cost pool, whereas there is no equivalent step in TC. Then, in the second stage, ABC allocates cost to a product based on the usage of the activities by the product from the cost pools using the cost drivers while TC uses hours or volume (Ray 2012:74). For ABC in the second stage, cost objects are allocated to each activity cost pool with the aid of activity drivers that represent cost object activity consumption patterns (Aldukhil 2012:53). The main reason for the introduction of ABC was therefore to improve the indirect cost allocation to avoid the distortion of cost from the TC allocation method.

ABC advocates have maintained that ABC is a robust costing system that reflects accurate product cost data (Aldukhil 2012:16), and various authors (Botha & Du Toit 2017:351; Dwivedi & Chakraborty 2016:290; Kumar & Mahto 2013:12; Osetoba et al 2019:53; Wen-Zheng & Yazid-Abu 2019:9) revealed that ABC calculates the indirect cost accurately. Therefore ABC is a system a company may implement to determine accurate indirect cost allocations, which may lead to more accurate product cost calculations and provide relevant costing information per product. The following section will discuss the advantages and disadvantages of ABC.

3.4 ADVANTAGES AND DISADVANTAGES OF ABC

The increasing complexity entailed in product-mix decisions has driven the need to introduce ABC (Mahal & Hossain 2015:71), but it should be noted that ABC has advantages and disadvantages. The following section will discuss the main advantages of using ABC.

3.4.1 Advantages of ABC

ABC has been classified as an influential tool for decision-making (Cooper & Kaplan 1988:103; Mahal & Hossain 2015:71). ABC provides more accurate product costs (Cooper & Kaplan 1988:103; Drury 2018:267; Alsayegh 2020:258). In addition, Drury (2018:267) revealed that ABC may benefit organisations with high indirect cost by allocating it to specific products using activities. Some advantages of ABC are discussed below.

- In order to assign indirect costs, ABC uses real cost activities that improve operational efficiency (Ali et al 2015:605).
- By concentrating on the cost interaction between cause and effect, ABC provides accurate and precise cost estimation (Mahal & Hossain 2015:71).
- ABC delivers more realistic product costs in an advanced manufacturing environment where indirect cost is a large proportion of the total costs (Salem & Mazhar 2014:44).
- ABC understands the true nature of activities that lead to costs; hence it reduces costs by identifying activities that do not add value to the product (Mahal & Hossain 2015:71).
- ABC assists management in determining where the most significant costs come from, and which activities contribute to it, thereby eliminating non-value activities (Nasution & Siregar 2018:3).
- ABC provides accurate product cost data, which strengthens the manager's ability to make the right decisions (Salem & Mazhar 2014:41).
- ABC provides accurate product cost, which assists in calculating the selling price (Mahal & Hossain 2015:71).
- The ABC system makes it easier to understand cost actions as it identifies the sources of indirect costs. It also allows tracking of costs to areas of management responsibility (Salem & Mazhar 2014:41).

- ABC aims to enhance the manufacturing process by identifying cost activities, and contributing to the improvement of the company’s competitive position (Salem & Mazhar 2014:41).

The advantages of ABC above have emphasised that ABC assists managers to understand the source of the costs when analysing activities, which leads to the elimination of non-value activities and more accurate product cost. Thus, ABC improves managers’ decision-making as they have accurate product cost information. While the advantages have been noted above, the disadvantages of ABC will be discussed in the section that follows.

3.4.2 Disadvantages of ABC

ABC has been recognised as a system that presents a more accurate allocation of indirect costs compared to the TC system (Salem & Mazhar 2014:41). However, based on Salem and Mazhar (2014), Mahal and Hossain (2015) and Cai (2018), there are disadvantages of the ABC system which will be listed below:

- The ABC system has multiple cost pools and different cost drivers which may be difficult to use compared to TC (Salem & Mazhar 2014:41).
- During the implementation of the ABC system, it may be difficult to identify cost drivers, allocate costs, and calculate multiple cost driver rates (Salem & Mazhar 2014:41).
- It is more expensive to operate the ABC than the TC system (Mahal & Hossain 2015:71).
- The management decision process may take time due to the complexity of the ABC system (Mahal & Hossain 2015:71).
- As there are large amounts of random data, ABC data may be easily misinterpreted (Mahal & Hossain 2015:71).
- The ABC system considers every step of production activity, which may cause an increase in the cost of implementing it (Cai 2018:44).

There is a high cost of managing ABC, which is associated with the system's complexity. Also, the process of identifying the cost drivers is complex which may lead to the companies deciding not to use the system. Therefore, when the decision to implement ABC is taken, companies should consider the disadvantages. The following section will discuss the factors to consider when implementing ABC.

3.5 FACTORS TO BE CONSIDERED WHEN IMPLEMENTING ABC

ABC implementation should include all divisions of the company as the risk of failure increases if only the finance team is involved in its implementation (Intakhan 2014:292). The decision on how ABC will be implemented should be a cross-division team's responsibility and the top management should fully support the process from the design to the implementation (Mahal & Hossain 2015:68).

- Before the implementation of ABC, the company must have a clear business process that shows activities and operational flows (Miller 2017:24). Ray (2012:75) concluded that preparations for implementing ABC should include describing ABC requirements for each team in the company, understanding the company's cultural and indirect activities that may affect ABC implementation, and describing the training requirements for company employees.
- Cross division teams should be identified, which have a clear understanding of the business flows. For example, to design an ABC system for a warehouse centre, the team should include several warehouse managers, logistics, supply, and finance employees (Miller 2017:25).
- Salem and Mazhar (2014:45) advocate that management should understand the importance of ABC. The company may decide to implement the system step-by-step to allow the managers to adopt and understand it.
- ABC should not be implemented as a solution for the cost control problem that is linked to a manager's bad spending behaviour. Rather, ABC should be implemented to provide guidance and improve management decisions (Ginoglou 2010:197).

- Top management support is needed as well as clear objectives of ABC implementation between ABC designers and users (Intakhan 2014:290). Research studies show that management support is essential for ABC implementation effectiveness (Aldukhil 2012:77).
- ABC implementation is not a small project. The project needs to be well managed since ABC is not a mandatory regulatory reporting tool. The intended benefits and objectives of implementing ABC must be analysed and understood (Ray 2012:77).

The above factors should be considered before a decision to implement ABC is made by management, including having clear objectives of why ABC is being implemented and having the full support of the system by management. The next section will include a discussion about the main steps to be followed by companies for the successful implementation of ABC.

3.6 STEPS FOR THE SUCCESSFUL IMPLEMENTATION OF ABC

ABC design may appear complicated, but if the company is familiar with the roots of its cost, it becomes less complicated. To simplify the design, four steps in the ABC implementation process need to be followed, namely, identifying activities, assigning resource costs to activities, selecting activity cost drivers to cost objects, and assigning costs of activities to products (Yousif & Yousif 2011:12; Drury 2018:263). The sections that follow will discuss the four steps of implementing ABC in more detail.

3.6.1 Step 1: Identifying activities

Activities are the combination of units of action that are defined by verbs related to the specific task (Fountaine 2011:28), therefore it is the element that happened to obtain the results. For example, placing the order is the activity that leads to sales of the specific product ordered. All work carried out within the company may be linked to an activity (Yousif & Yousif 2011:13). The process of gathering relevant data from existing documents or records and interviewing individuals involved in the process may be done as part of identifying the activities (Drury 2018:264).

A single event or a collection of acts may be classified as an activity (Blocher, Stout, Cokins & Chen 2010:122). There are four classifications of the production process activities, namely: unit-level activities, batch-level activities, product-sustaining activities, and facility-sustaining activities (Nasution & Siregar 2018:4). Of the four levels, indirect costs are mainly incurred in the facility-sustaining activities (Nasution & Siregar 2018:4). This is the level that includes production process activities that are not directly linked to the production of specific products, also known as indirect production cost. At the time of identifying activities, it is crucial to identify irrelevant and relevant activities and be able to group activities having similar objectives (Madwe 2017:43). In the process of refining petroleum products there are multiple activities. Table 3.1 below presents the main processes and related activities in crude oil refineries.

Table 3.1: Identification of main processes and related activities in the crude oil refineries

Unit	**Activity**
Desalting process	Crude oil desalting
Crude distillation unit	Distillation
Vacuum distillation unit	Vacuum
Thermal cracker	Chemical cracking
Hydrotreaters	Removing of sulphur
Separators	Gas separator
Naphtha splitter	Separation of naphtha
Catalytic reformer	Conversion process
Gas treating	Gas treating
Blending pools	Product blending
Stream splitters	Product split

Source: Own interpretation based on Mohamad (2012:3-32)

Table 3.1 describes the standard activities involved in the process of refining petroleum products, for example, the crude distillation unit which is linked to the activity of distillation. The process of isolating activities needs a great deal of judgment as it can take time and is often challenging (Yousif & Yousif 2011:13). However, based on the activity dictionary, a document that identifies and describes each of the activities within a company, it is recommended that the standard activities are identified (Yousif & Yousif 2011:13). Also, for the costs to be allocated properly, activities need to be independent of each other (Kaplan & Cooper 1998:85-86). For example, in Table 3.1, the vacuum activity is independent of any other activity listed.

3.6.2 Step 2: Assigning cost to activities

Once the activities are known, the next step is to allocate the indirect costs to each activity using first-stage cost drivers, which link the costs to activities performed (Drury 2018:264). Therefore, the activity performed is grouped into activity centres, which represents a group of interrelated activities underlying a process, role or department (Aldukhil 2012:53). ABC uses the cost of resources consumed to allocate resources to activities based on cause-and-effect (Yousif & Yousif 2011:13). Based on the historical trend, the company may estimate how much each activity and process costs to perform (Kaplan & Cooper 1998:86). Therefore, it is important for the company to clearly identify activities and group them to the correct activity centres to be able to allocate the indirect cost accurately.

Blocher et al (2010:130) state that the costs of resources are allocated to the activities that are the real cause of the indirect cost, and then the cost of the activities will be used to determine the selling price of the product. They further explain that various costs can be traced directly to specific activity centres, such as fuel costs used to run a machine pump which can be identified by reading the fuel usage meter (Blocher et al 2010:129-132). Therefore, the management may view the full cost of each activity from the specific activity centre when they make a decision.

3.6.3 Step 3: Selecting appropriate cost drivers

Cost drivers are those elements that may be used to assign the actual costs in line with the activities (Wen-Zheng & Yazid-Abu 2019:2). Furthermore, cost drivers cause a change in the cost of activities (Kumar & Mahto 2013:3). Cost drivers illustrate why the activity is part of the production process and how long it will take for the activity to be completed (Turney 1991:87). Yousif and Yousif (2011:14) added that cost drivers monitor and calculate the cost of conducting activities and show the frequency at which the cost increases with the level of activity. Aldukhil (2012:54) contends that cost drivers are mainly non-financial data that enable managers to identify process improvement opportunities. Hence, in each operational cost centre, cost drivers should have a clear description (Drury 2018:264).

There are two types of cost drivers, namely quantitative and transactional cost drivers (Cai 2018:23). A quantitative cost driver calculates the number of resources used by an activity while a transactional cost driver counts the number of activities performed for a cost object (Madwe 2017:7). The strong link between cost drivers and activities may be identified before the cost is allocated to the product in order to have an accurate allocation driver. (Wang, Du, Lei & Lin 2010:377). Hence, it is important to identify the cost drivers that relate to production process activities to calculate product cost accurately.

3.6.4 Step 4: Assigning the cost of activities to products

The last step in the ABC implementation process is to allocate the costs of the activities to the product. To calculate the product cost, the direct and indirect costs of each cost activity are added together (Bvumbi 2017:18). ABC allocates the indirect costs incurred by each activity to products based on its consumption (Chouhan et al 2017:137). Hence, the costs should be allocated to the specific product using the appropriate cost drivers' activities (Chouhan et al 2017:140).

The steps of implementing ABC discussed above show that a detailed analysis of activities and understanding of the production process should be performed to be able to link the activities to cost drivers. ABC systems may be implemented with fewer challenges when each step is completed properly as the steps are all dependent on each other, for example, without identifying and understanding activities, it will not be possible to assign costs to activities and subsequently select appropriate cost drivers. The section below will briefly describe the key factors that may be used as an indication that ABC has been implemented successfully.

3.7 ABC IMPLEMENTATION KEY SUCCESS POINTS

Once the decision to implement ABC is taken and ABC has been implemented by following the proposed steps set out in the previous section, there are implementation key success points that may be observed to determine if ABC has been implemented successfully (Intakhan 2014:289). Figure 3.2 shows the six ABC implementation key success points.

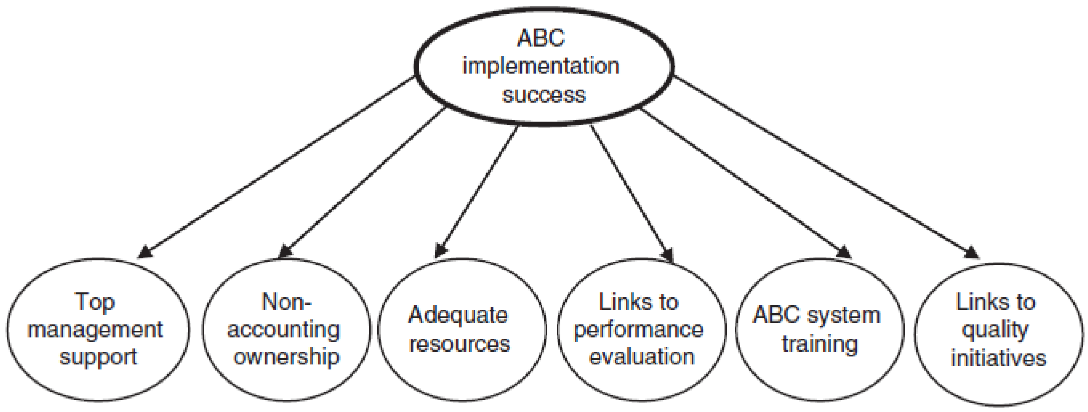


Figure 3.2: ABC implementation key success points
Source: Intakhan (2014:289)

In Figure 3.2, six key success points for ABC implementation are indicated. The first point involves top management's understanding of and support for ABC implementation for the company, and not only for the finance team. Non-accounting ownership, the second point, indicates that ABC should not be implemented only for finance employees. Number three shows that adequate resources should be available and number four, that performance evaluation should be linked to ABC. ABC system training is the fifth point to be taken into account. Lastly, ABC may be linked to quality initiatives. Therefore, when management assess if ABC implementation was successful their analysis of the key points in Figure 3.2, if there were achieved or not, may form part of the assessment report. The following section is based on the scholarly literature regarding benefits derived from ABC adoption.

3.8 BENEFITS DERIVED FROM ABC ADOPTION

The total product cost should include the cost of research and development, design and manufacturing cost, as well as the marketing costs of the product (Ray 2012:72). Therefore, to have accurate product costs, indirect costs should be carefully identified and allocated accurately to the products.

As much as this study focused on the petroleum industry, the ABC literature has described the benefits across different industries and sectors. Although the study of Niasti, Fazaeli, Hamidi and Viaynchi (2019) is in a private hospital, Durán and Durán (2018) on wastewater, Miller (2017) on transportation, and Kosmas and Dimitropoulos (2014) on sport, they all agreed that ABC determines accurate product cost. Therefore, the benefit of ABC may be similar across different sectors and industries. Various benefits have been derived from ABC adoption, the body of knowledge in the past 10 years have identified multiple benefits of adopting ABC in different sectors and industries worldwide. The purpose of the scholarly literature listed in Table 3.2 is to display the benefits of ABC in different sectors or industries. The studies listed describe various benefits of ABC including the accuracy of product cost which leads to decision making as to the benefit of adopting ABC.

Table 3.2: Benefits derived from adopting ABC

Benefit	Source	Context of study	Finding related to ABC adoption
Accurate product costs	Kosmas & Dimitropoulos (2014)	Public sports organisation in Greece	Calculating the cost of athletic activities using ABC was more accurate than under TC.
	Miller (2017:22)	Logistics companies in America	Using ABC results in improved delivery cost.
	Abu, Jamaludin & Zakaria (2017)	Malaysian manufacturing companies that remanufacture the crankshaft. Analyse the TC allocation of indirect cost versus ABC	The indirect costs are allocated to a specific crankshaft based on the number of activities required to re-manufacture the crankshaft, which leads to accurate costing of each crankshaft.
	Durán & Durán (2018)	Wastewater treatment in Switzerland	ABC allocates costs appropriately to the products that generate those activities which leads to accurate product costs.
	Niasti et al (2019)	Radiology services in Beheshti hospital of Hamadan	There are differences between the real price of radiology services and approved tariffs, caused by the distortion of cost allocation, hence ABC provides more accurate costing.
	Sembiring et al (2017)	Cost allocation at manufacturing industry particularly in Palm Oil Mill still widely practiced based on estimation. It causes cost discrepancies.	When calculating the cost of items manufactured of Crude Palm Oil using the ABC method, the result is lower than when using the old method, indicating that ABC reduces overhead indirect cost distortion and calculates accurate product costs.
	Nasution & Siregar (2018)	Determination of product cost with ABC, in the manufacturing companies in Egypt	Calculation of product cost with TC system which is volume-based - does not reflect accurate product cost while ABC provides accurate costing.
	Al-Eidan ,Al-Ahmad, Al-Ajmi , Al-Sayed, Al-Ajmi & Smew (2019)	ABC for manufacturing costs reduction and continuous improvement: A case study where ABC is used to investigate XYZ costing system	By allocating each cost to its resources and activities, the ABC technique is a valuable tool in generating accurate cost information data.

Benefit	Source	Context of study	Finding related to ABC adoption
Accurate product costs (continued)	Osetoba et al (2019)	Reduction of crude oil production cost in Nigerian indigenous company using ABC	The ABC identified cost of non-adding value activities and reduce the cost relate to it and identify value adding activities, which may lead to accurate product cost
	Alawadi, Alrajawy & Bhaumik (2019)	Effect of Value Chain Analysis and ABC of United Arab Emirate Petroleum firms taking into account the effects of calculating product cost using ABC	ABC assist on calculation better costs of production, more accurate information which provide accurate data for decision making for all levels of management
Accurate profitability of products	Faraj (2017)	Private Lebanese hospital	ABC calculates different unit costs accurately, which leads to the changes that result in improved accuracy of revenue centres profitability.
	Raucci & Lepore (2020)	Italian small road company	Through ABC, the cost relating to item returns may be traced to its origin item, which leads to accurate profitability.
	Wen-Zheng & Yazid-Abu (2019:9)	Palm oil plantation in Malaysia	ABC provides actual cost information and proper cost drivers for each of the activities involved. Therefore, it improves the accuracy of the company's profitability information.
	Kabinlapat & Sutthachai (2016)	Food manufacturing corporation in Thailand	The results from the ABC analysis revealed significant differences in unit costs derived from ABC compared to the existing cost system, therefore, ABC calculates costs accurately, which also improves the accuracy of the profitability information of products.
Improves financial performance	Oseifuah (2013:40)	Public sector	In the public sector, the costs are not incurred due to the production activities, but they are incurred due to the supporting activities, hence, ABC may assist the public sector to make the correct decisions and take action to improve financial performance.
	Salehi, Hejaz, Manesh & Bulvar (2010:42)	Public Iran Gas company	One of ABC's key factors to non-profit organisations is that it helps companies establish the foundations of a management-oriented accounting method that may improve its financial performance.

Accurate data for decision making	Oseifuah (2013:49)	Public sector (Municipality) in South Africa	The use of ABC offers valuable data and cost data to the public sector enabling the enhancement of service quality and decision-making.
	Amiri & Khmidi (2018)	Nursing unit at Taiwan Hospital in Canada	The usefulness of the ABC system has been verified as it provides managers with precise costing information to make effective decisions
	Watanapa, Pholwatchana & Wiyaratn (2016)	Train stations in Thailand	ABC provides accurate information which leads to the strategic management decision.
	Reynolds & Van der Poll (2015)	ABC implementation in South Africa - Nelson Mandela Bay: How far should manufacturing organisations go?	The use of ABC in conjunction with capital investment decisions may ensure that correct decisions are made when critical long-term projects are considered.
	Almeida & Cunha (2017)	ABC on a manufacturing company in Portugal	ABC offers a broad range of highly informative, applicable, and useful knowledge for decision-making.
	Kabinlapat & Sutthachai (2016)	Food corporation in Thailand	ABC approach solves the product cost distortion and provides the management with more reliable cost information.
Improves financial performance	Oseifuah (2013:40)	Public sector	In the public sector, the costs are not incurred due to the production activities, but they are incurred due to the supporting activities, hence, ABC may assist the public sector to make the correct decisions and take action to improve financial performance.
	Salehi et al (2010:42)	Public Iran Gas company	One of ABC's key factors to non-profit organisations is that it helps companies establish the foundations of a management-oriented accounting method that may improve its financial performance.

Accurate data for decision making	Oseifuah (2013:49)	Public sector (Municipality) in South Africa	The use of ABC offers valuable data and cost data to the public sector enabling the enhancement of service quality and decision-making.
	Amiri & Khmidi (2018)	Nursing unit at Taiwan Hospital in Canada	The usefulness of the ABC system has been verified as it provides managers with precise costing information to make effective decisions.
	Watanapa et al (2016)	Train stations in Thailand	ABC provides accurate information which leads to the strategic management decision.
	Reynolds & Van der Poll (2015)	ABC implementation in South Africa - Nelson Mandela Bay: How far should manufacturing organisations go?	The use of ABC in conjunction with capital investment decisions may ensure that correct decisions are made when critical long-term projects are considered.
	Almeida & Cunha (2017)	ABC on a manufacturing company in Portugal	ABC offers a broad range of knowledge that is highly informative, applicable, and useful for decision-making.
	Kabinlapat & Sutthachai (2016)	Food corporation in Thailand	ABC approach solves the product cost distortion and provides the management with more reliable cost information.
	Al-Eidan et al (2019)	ABC for manufacturing costs reduction and continuous improvement: A case study where ABC is used to investigate XYZ costing system	Enhanced costing simulations using ABC can guide the XYZ Company management decision.

Source: Own interpretation – compiled from acknowledged literature sources

The studies presented in Table 3.2 from different industries and sectors have shown the various benefits of adopting ABC and how it improves companies' costing information and decision making. They also describe how product cost may be calculated more accurately using ABC than TC. As much as they are from various countries, industries or sectors, the main benefit is that ABC calculates a more accurate product cost. There are few studies on crude oil refineries which demonstrate ABC benefits. The study by Almeida and Cunha (2017) states that ABC provides a broad range of knowledge that is highly informative and useful for decision-making in the manufacturing sector. Abu, Jamaludin and Zakaria (2017) also provide an overview of how ABC allocates cost to achieve accurate product costing. Wen-Zheng and Yazid-Abu (2019:9) confirmed that ABC enables accurate product costing of the manufacturing plant and achieves the accurate profitability calculation for each product. Osetoba et al (2019:53) on the crude oil production cost stated that ABC can identify non-value-added activities which may reduce cost and lead to the accurate product cost. In addition, Alawadi et al (2019:505) on a petroleum firm, revealed that ABC may calculate better costs from the value chain. In the petroleum industry, especially in South Africa, ABC is not visible in the current calculation of the cost of petroleum products. Considering the implied benefits of ABC, this study will explore the adoption of ABC in selected South African crude oil refineries, part of the downstream segment of the petroleum industry value chain.

The discussions reflect that ABC allocates indirect costs more accurately to the specific product and provides more accurate profitability information per product. The section that follows will discuss how ABC can be used in conjunction with optimisation theory.

3.9 ABC THROUGH THE LENS OF OPTIMISATION THEORY

Optimisation is in the centre of a situation where decisions must be made between two or more activities, whether in real life or in business activities. The decision is made considering the various options that may bring forth different results, but the person should choose the option that will lead to optimal results.

3.9.1 Optimisation theory

Lockhart and Johnson (1996:610) define optimisation as "the process of finding the most effective or favourable value or condition". Optimisation aims to obtain the best results from the set of guidelines or constraints. The guidelines or constraints may include optimising variables such as productivity, power, reliability, durability, output, and utilisation. One of the simplest definitions for optimisation is "doing the most with the least" (Gomez et al 2006:301). Therefore optimisation may be used to analyse different scenarios to determine the optimal product mix.

Optimisation models are based on objective elements that should be reduced (or increased) in consideration of various constraints (Sayyadi & Awasthi 2016:2). Optimisation theory may include sensitivity analysis, which defines the effect of element variation to determine the optimisation point (Sayyadi & Awasthi 2016:11). According to Saremi et al (2017:30), optimisation problems arise from various fields of studies. The constraints should be defined based on the existing scenarios. Then, different steps need to be taken to optimise based on the existing constraints. It is important to recognise the new constraints added to each scenario before a suitable optimiser is chosen.

For optimisation, South African refineries use a linear programming model, a mathematical evaluation methodology, which is applied to determine the optimisation point of the refinery (Du Pont 2004:44). In South Africa, the BFP is used in the linear programming model to determine the profitability of the optimal point (Du Pont 2004:44). The refinery optimisation model forms the refinery backbone not only for assessing the margins and product mix, but also for optimising business decisions, crude purchasing and crude to be processed (Du Pont 2004:40). Therefore, the linear programming model gives suggestive optimal results using the BFP which is a deemed cost and is not directly linked to the actual production cost of each refined petroleum product.

The strain from global industries' competitiveness has made the effective, efficient, and continuous development of production processes an important success factor (Gröger, Niedermann & Mitschang 2012:1). Hence, finding and using a system that optimises the cost-intensive area of production is now not only a trendy practice, but an important business strategy (Marzantowicz 2016:118). The theory and techniques of optimisation have grown in their capacity to address numerous practical concerns in the production process (Tsai, Carlsson, Ge, Hu & Shi 2012:1). Therefore, optimisation theory may improve the refinery planning production process by determining the optimal economic product mix.

One of the characteristics of optimisation theory is to find the most effective optimal point of the scenario. For the production process, the optimal point may be the point with the highest production which may lead to a profitability increase for the company. Considering the characteristics of ABC and optimisation theory's main objectives, it is argued that refineries may improve their performance when they use ABC in conjunction with optimisation theory. The section below will discuss the application of optimisation theory in ABC.

3.9.2 Application of optimisation theory in ABC

Optimisation may contribute to the profitability of the company (Santana, Afonso, Zanin & Werneke 2017:1183). Singer and Donoso (2007:344) state that a consistent optimisation model may assess several strategic decisions. It is therefore plausible that if ABC is used by South African refineries to calculate accurate product costs of selected regulated products, new optimisation scenarios may be identified. Furthermore, the optimisation scenarios could indicate the optimal point and / or product mix, which in turn may lead to decisions that positively contribute to refinery profitability. The study of empirical validation of an activity-based optimisation system by Singer and Donoso (2007:344) revealed that ABC may be used to determine the production process activities, to calculate product cost, and review the feasibility of producing each product. Therefore, ABC and optimisation may be adopted to optimise the refinery operation.

3.10 SUMMARY

The measurement of the full cost of products and services is based on accounting data. Interpreting and reviewing this costing data assist companies in understanding their costing process. The TC method allocates indirect costs to products based on volumes or hours, while the ABC system allocates indirect costs based on activities. ABC provides an accurate allocation of indirect costs and reduces the cost subsidisation between products.

There are advantages and disadvantages to using ABC. It has the following advantages: it provides more realistic product costs, it understands the true nature of activities that lead to cost, it assists management in determining where the most significant costs come from, which may lead to the elimination of non-value activities, it provides accurate product cost data, and it makes it easier to understand cost actions by identifying the sources of indirect costs. The disadvantages of the ABC system are that it has multiple cost pools and different cost drivers, making it difficult to identify cost drivers, allocate costs, and calculate multiple cost driver rates. It is also more expensive to operate the ABC system than the TC system, and the management decision-making process may take longer due to the ABC system's complexity.

There are four steps to implementing ABC which are identifying activities, assigning resource costs to activities, selecting activity cost drivers to cost objects, and assigning costs of activities to products, which need to be followed to simplify its design. To measure the success of ABC implementation, there are six key success points namely top management support, non-accounting ownership, adequate resources, links to performance evaluation, ABC system training, and links to quality initiatives. Multiple sectors and industries have implemented ABC successfully and have enjoyed various benefits of using ABC including the more accurate product costs and determining accurate cost data for decision making

Optimisation is in the middle of a situation when a decision between two or more activities should be made, in real life or business activities. South African refineries currently use the LP model to optimise the refinery. In the model, the BFP is applied, which is the deemed cost of refining petroleum products to calculate the profitability of the optimal point. With ABC allocating indirect costs more accurately to specific products, the application of ABC through the lens of optimisation theory may be useful for subsequent optimal product mix decisions between selected regulated products. The following chapter will discuss the research design and methodology adopted for this study.

CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

In Chapter 2, the first research objective was met, which was to review the petroleum refinery value chain, considering the deemed cost of selected regulated products in South Africa. Chapter 3 met objective 2 by defining the concepts associated with ABC, explaining how ABC emerged from TC, and providing the benefits and challenges of ABC. Based on the literature, Chapter 3 also discussed ABC through the lens of optimisation theory.

The purpose of this chapter was to determine the most suitable research method to meet the third and fourth research objectives. The third objective explores the refinery processes in determining the optimal product mix and effect of COVID-19 in selected South African refineries. The fourth research objective is to explore the refinery managers' opinions on the costing currently used and ABC adoption considerations for selected regulated petroleum products in South Africa. This chapter, therefore, explains the research design and methodology of the empirical study that was undertaken for meeting objectives 3 and 4.

This chapter puts forward the research strategy and methodology, followed by an explanation of the research paradigm. Thereafter, the research design was presented, illustrating the distinction between qualitative, quantitative, and mixed-method designs. The chapter also included various elements of research methodology, including a description of the research instrument, the population, and the sampling strategy. It further explained the method of gathering data and how the data were analysed. Lastly, it discussed the phases and factors considered to ensure the research validity, reliability and trustworthiness, methodology limitations as well as ethical considerations.

4.2 RESEARCH APPROACH

The research approach is a method and technique that varies from general assumptions to comprehensive information gathering, assessment and analysis of data (Creswell 2014:31). This is also called methodology, referring to how we approach issues and look for answers, the point of view and purpose (Taylor et al 2016:3). Research methodology includes the philosophical assumptions, the basis of the research and the implications of the findings for the approach or method used (Saunders & Rojon 2014:77).

There are three different methodologies namely quantitative, qualitative, and mixed methods (Denzin & Lincoln 2005:3). Quantitative methodology is concerned with statistical data that is analysed using quantitative techniques, especially numbers, while qualitative methodology is concerned with what people are communicating and understanding, as well as how they respond or interact in response to a scenario (Taylor et al 2016:5). Denzin and Lincoln (2005:3) state that qualitative research attempts to interpret phenomena according to the meanings that people bring to them. The information from RMs and FMs in the study gave an understanding from the managers' opinions on ABC adoption considerations and refinery processes to subsequently inform optimal product mix decisions of selected regulated petroleum products in South Africa. Therefore, this study used the qualitative methodology as it allows for rich data to be collected from human understanding. The following section defines the research paradigm and substantiates the paradigm chosen for this study.

4.3 PARADIGM

A paradigm is a common point of view or set of ideas; it is an approach of looking to something (Guba & Lincoln 1994:107). Burrell and Morgan (2016:22) provide four social science research paradigms, depicted in Figure 4.1.

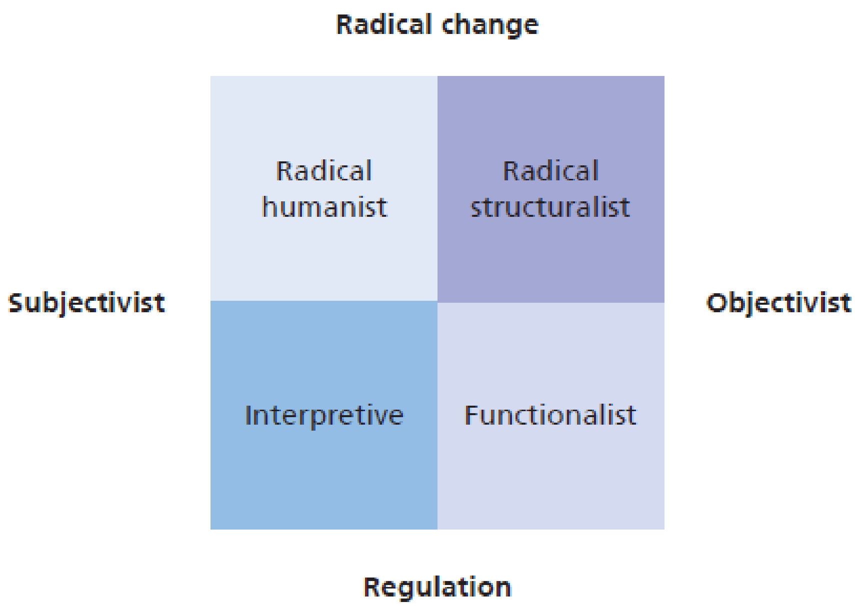


Figure 4.1: Research paradigms
Source*:* Burrell & Morgan (1979:22)

Figure 4.1 illustrates four possible research paradigms, namely, radical humanist, radical structuralist, interpretive and functionalist. The radical humanist is concerned with developing a sociology of radical change while the radical structuralist objectivist viewpoint is concerned with developing a sociology of fundamental change (Burrell & Morgan 1979:26-31). The functionalist research paradigm is typically based on a positivist research theory, and it aims to offer logical solutions to rational problems (Saunders, Lewis & Thornhill 2018:140-141). The interpretive paradigm is motivated by the ability to reason the basic sense of the social world on a subjective level and to perceive the world as it is (Burrell & Morgan 1979:26). The paradigm of interpretivism consequently interprets the universe at the level of subjective experiences of participants (Burrell & Morgan 1979:28). According to Rehman and Alharthi (2016:55), interpretive research aims to understand people's perceptions from their social experiences. Greener and Martelli (2015:42) stated that an interpretive paradigm is normally adopted in a qualitative research approach such as conversation analysis or interviews to understand a specific concept. An interpretive paradigm was, therefore, selected for this study as the opinions of certain managers with regard to their subjective experiences in the refineries were explored. The next section discusses the chosen research design.

4.4 RESEARCH DESIGN

The research design is the use of knowledge systems, regulations and guidelines that include the research instrument, system, and structure for conducting research (Majid 2018:1). It is a broad technique plan for a research problem (Greener & Martelli 2015:42). Creswell and Creswell (2018:11), state that research design provides the researcher with a blueprint for the procedures in a research study and are types of inquiry within qualitative, quantitative, and mixed methods approaches. The procedures referred to, give direction for the data to be collected, the method of data collection, the data analysis method and includes ethical considerations. Ritchie et al (2013:4) contends that the qualitative design asks questions based on what, why, and how. As previously indicated, this study used a qualitative research methodology, therefore in line with this, a qualitative research design was used. The following section discusses the elements of research methodology.

4.5 ELEMENTS OF RESEARCH METHODOLOGY

The research methodology can be denoted as the “nitty-gritty” of the study (Hofstee 2006:115). An empirical study is a study that is focused on observation and evaluation of activities in which the findings are focused on the analysis. Abdulai and Owusu-Ansah (2014:8) revealed that when collecting and analysing data, there are various elements of research methodology to be considered, including the research instrument, population, sampling, data collection and data analysis. The below subsections elaborate on these five elements.

4.5.1 Research instrument

To gather information about a certain topic, the researcher uses specific tools as research instruments. The primary researcher is also a research instrument in a qualitative study because when interviews are conducted, participants' reactions must be observed (Yilmaz 2013:317). In order to direct participants in answering a specific research question, interviewing is a frequently used approach of acquiring data (Stuckey 2016:56). When acquiring data, the researcher should maintain close contact with the subjects (Yilmaz 2013:317). Kallio, Pietila, Johnson and Kangasniemi (2016:17) provide guidance on interviews, which include five phases, with the first phase identifying the criteria for using semi-structured interviews, the second phase locating historical data to use, the third phase developing the interview guide, the fourth phase pre-testing the interview guide, and the fifth phase is submitting the final interview guide adjusted for changes from the pre-test phase.

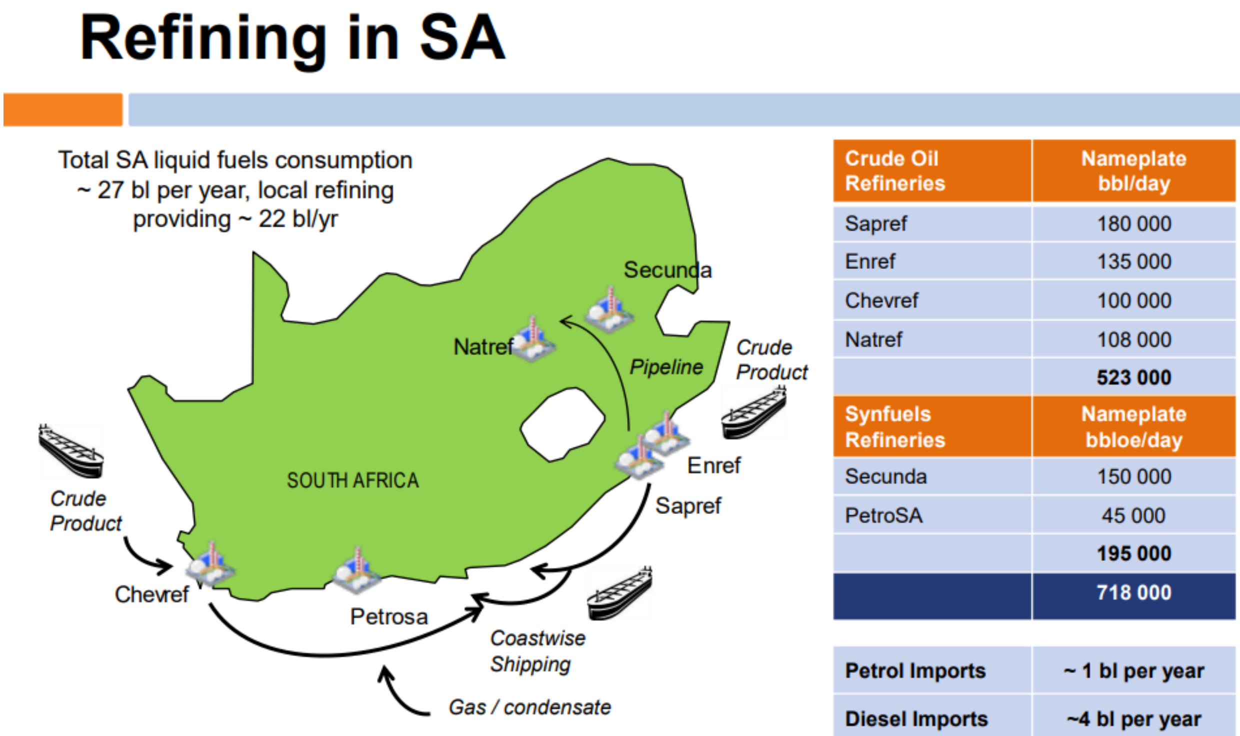
There are three types of interviews to choose from namely, structured, narrative and semi-structured interviews. Structured interviews are used when the data provided by the participants are tightly controlled by the questions asked because the researcher asks a set of structured questions with a limited number of possible responses. Narrative interviews follow a process where data is mainly focused on the unfolding of occurrences from the life experience of a participant. Semi-structured interviews are a form of interview allowing flexibility whereby the researcher determines the subjects to be discussed, but the participants' responses determine how the interview is conducted (Stuckey 2016:56). The main distinction between the different interviews is the amount of control the interviewer has over the discussions and the objectives of the interview (Stuckey 2016:56). Semi-structured interviews were adopted for this study as they provided the flexibility to explore the managers' views.

Kabir (2016:211) stated that the interview guide is a list of questions and subjects that are discussed during the interview, usually in a specific order. Kallio et al (2016:17) added that compiling a methodical and clear interview guide provides a strong contribution to the efficiency of the semi-structured interview. In addition, Stuckey (2016:58) contends that for efficient and effective semi-structured interviews, the researcher should prepare the interview guide in advance. The interview questions for this study were self-designed, informed by the literature review, and prepared in advanced to ensure efficiency and effectiveness. The interview guides used had three parts. The first two parts required participants to answer questions at their own pace, which they could choose to answer before the interview, or during the interview. These gave the participants the opportunity to take their time and think about the answers they provided. It also reduced the pressure on the participants as they could answer the questions at their own pace. The third part was an audio interview in which the researcher verbally asked the questions to the participants. For interview efficiency, the questions were arranged into two interview guides, each tailored to a certain group of participants, with both included in Appendix D. The first interview guide was for the FMs and the other one for the RMs. The two interview guides were pretested for efficiency and effectiveness with two managers, one from each group, who were not sampled participants.

From the pre-test interviews, the two participants understood the questions in the interview guides and answered the questions with direct answers. This indicated that the questions from the interview guides were understandable and could provide rich data to be able to meet the objectives of the study, leading to the interview guides being finalised. The following subsection will discuss the population of the study.

4.5.2 Population

The study population refers to the people who may be examined as part of the research study (Majid 2018:2). South Africa has six operational refineries (OPEC 2019:41), four on the coast and two inland (SAPIA 2016:5) (Figure 4.2). Four of these refineries produce petroleum products from crude oil (SAPIA 2016:5). Therefore, the study population is the individuals from the four crude oil refineries who are able to provide informed responses to the questions in the interview guides.



Crude Oil Refineries	Nameplate bbl/day
Sapref	180 000
Enref	135 000
Chevref	100 000
Natref	108 000
	523 000
Synfuels Refineries	**Nameplate bbloe/day**
Secunda	150 000
PetroSA	45 000
	195 000
	718 000
Petrol Imports	**~ 1 bl per year**
Diesel Imports	**~4 bl per year**

Figure 4.2: A map of South Africa indicating the location of refineries and their capacities
Source: SAPIA IMO (2019:6)

Figure 4.2 indicates the location of six South African refineries. The four crude oil refineries have crude oil throughput of barrels per day ranging from 100 000 for CHEVREF, 108 000 for NATREF, 135 000 for ENREF, to 180 000 for SAPREF. Although much of this data is for 2019, the throughput capacity of the refineries has not changed significantly (SAPIA 2021). The following subsection will discuss the sampling.

4.5.3 Sampling

Sampling is the process of choosing a specific number of users from a larger population in such a way that results from the selected minority can be used to make decisions about the larger population (Taherdoost 2016:20). Figure 4.3 shows the types of sampling techniques.

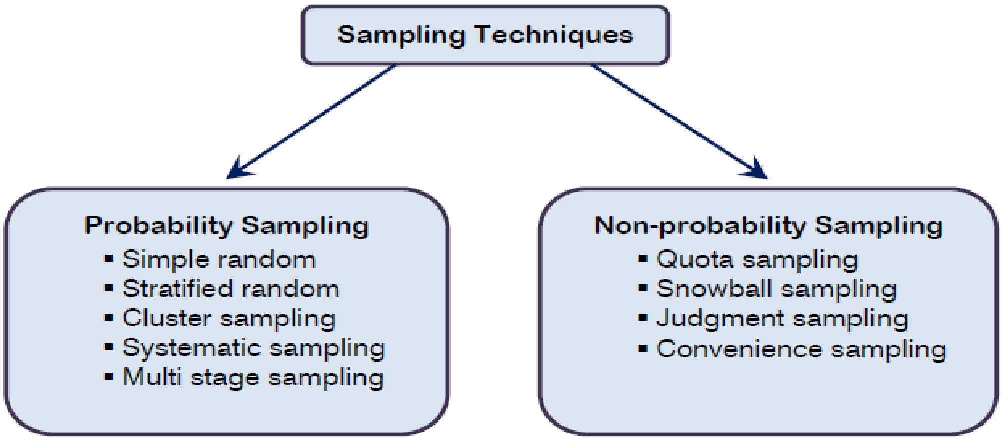


Figure 4.3: Types of sampling techniques
Source: Taherdoost (2016:20)

There are two main types of sampling techniques, namely, probability sampling and non-probability sampling (Figure 4.3). Probability sampling assumes that every member of the population has the same chance of being included in the survey, while selection bias occurs in non-probability sampling. Non-probability sampling is often used when there is no intention of making statistical inferences in relation to the wider population or when a real-life phenomenon gets examined. Hence, case study research design and qualitative research are frequently correlated with non-probability sampling (Taherdoost 2016:20-22). This study used non-probability sampling because it employed a qualitative approach, and no attempt was made to generalise the results. Four non-probability sampling techniques are available (Figure 4.3):

- Quota sampling follows a non-random sampling method in which participants are chosen based on predetermined characteristics (Lamm & Lamm 2019:55).
- Snowball sampling is a non-random sampling method that employs multiple scenarios to allow for the addition of various cases in the study, thereby increasing the sample scope (Taherdoost 2016:21).

- Purposeful or judgmental sampling is a method in which unusual environments or events are purposefully selected to provide useful data (Taherdoost 2016:23).
- Convenience sampling participants are chosen when they are most accessible and convenient (Taherdoost 2016:23).

From the four sampling techniques explained above, purposeful or judgmental sampling allows the researcher to choose the sample based on the information or expertise required (Taherdoost 2016:23). As this study needed to gather knowledge from individuals with expertise, purposeful sampling was applied. A non-probability selection process was used to choose specific refineries and participants since it permitted the researcher to aim for refineries that met certain criteria and the precise people with enough knowledge on a specific subject. As indicated in section 1.6, with the view of refinery processes and ABC for coastal and inland costing, it was decided to focus on two crude oil refineries in South Africa, namely SAPREF and NATREF. SAPREF was selected because it is situated at the coast and is the refinery with the highest throughput, while NATREF is inland and is an advanced full-conversion refinery.

The sample of participants is based on the managers with experience in the refinery operation, optimisation and product costing from the selected refineries. There were two groups of participants. The first group was the FMs and the second group the RMs. The FMs were selected as they have extensive experience of refinery product costing and were deemed to understand ABC while the RMs are managers with experience in the refinery operation and optimisation. According to Intakhan (2014:292), to reduce the risk of ABC implementation failure, all divisions of the organisation should be involved. The same principle would apply to ABC adoption. Therefore, the reason for having FMs and RMs is to explore the opinions of managers from the different divisions on ABC. The difference between refinery managers and optimisation/planning managers is that refinery managers oversee all daily operations of the refinery, from manufacturing to ensuring policies and procedures are followed, while optimisation/planning managers are determining the most efficient way to process crude oil in order to increase revenues, comply with environmental requirements, fulfil contract agreements to customers, and take product mix or crude oil decisions.

Initially, there were 10 selected participants based on purposeful sampling from the two groups of managers, namely four FMs, and six RMs. However, data could not be collected from all the RMs initially selected, as discussed below.

4.5.4 Data collection

All data gathering aims to capture high-quality information that may be used to provide a convincing and credible response to the questions posed, resulting in rich data interpretation and analysis (Kabir 2016:202). Kabir (2016:202) further explained that the systematic gathering and measuring of data on variables of interest to answer specific research questions and analyse data is known as data collection.

The participants were invited via email to participate in the study and, where required, telephone calls were used to follow up on the invitations. The primary researcher conducted the interviews with the research participants via Microsoft Teams during the agreed time as per Microsoft Team's invitation. The interviews took approximately 45 minutes per participant and were audio-recorded. Data were collected from knowledgeable participants from the companies that manage SAPREF and NATREF. The FMs and RMs have provided the information on the refinery production cost, costing, indirect cost and ABC while the RMs have provided the information on the refinery optimisation and the impact of COVID-19 in the refineries.

According to Saunders and Rojon (2014:7), the data may be collected until the collection of additional data no longer shows something new, which is known as data saturation. For the current study the plan was to interview 10 participants, but as three of these were not available, seven participants were interviewed. However, data saturation was reached with participant number six as by the sixth interview, no new information was gathered.

This indicated that the sample size was sufficient to meet the objectives of the study. The next subsection describes the analysis of the data collected.

4.5.5 Data analysis

Data analysis is an active method used to gain a deep understanding of what you have considered and to continually improve that understanding (Taylor et al 2016:169). The data collected from the seven audio-recorded online semi-structured interviews were transcribed by an independent transcriber to a transcript for each interview. Using the transcripts, the researcher consolidated the open-ended, qualitative dimensions of the responses into the two main groups of the sample: namely RMs and FMs. Given that the researcher designed a semi-structured interview guide for each of the two groups, the consolidation of the transcripts improved the standardisation of coding and ensured a consistent analytical framework. This assisted both the researcher and second coder to ease the coding processes in the Atlas.ti™ version 9. Both the researcher and second coder independently created anonymised Atlas.ti™ version 9 projects to create the codes. Creswell (2014:247) reveals six steps that may be followed for data analysis. Figure 4.4 below indicates the steps of analysing the data to validate the accuracy thereof.

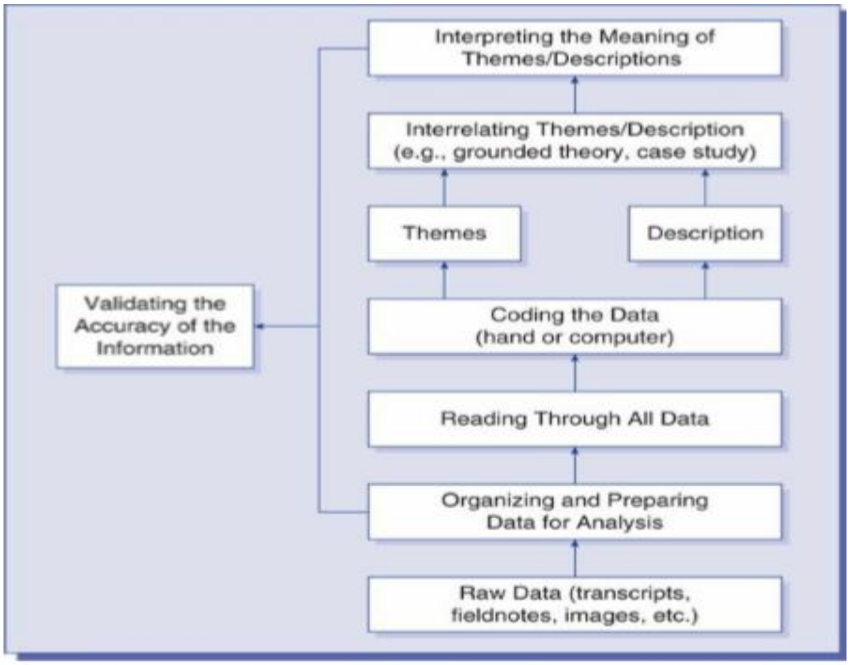


Figure 4.4: Steps of analysing data to validate accuracy
Source: Creswell (2014:247)

After the step of collecting the raw data (the transcripts), collectively, the six sequential steps that follow in Figure 4.4 enable the validation of the accuracy and ultimately the quality of the data, through guidance that included organising, coding, and interpretation of the coded data. Chapter 5 explains how the coding process unfolded in this study. In summary, in steps one and two, transcripts were developed from the audio-recorded interviews. In step three, the researcher and second coder read the transcripts to obtain a better understanding of the captured data. Step four was performed in Atlas.ti™ version 9, where projects were created to develop codes. This was followed by step five in which the codes were developed into categories, themes and subthemes. Lastly, in step six, the themes were interpreted and linked to objectives.

Data may be examined by means of the continuous comparative method (Strauss & Corbin 1990). Saldaña (2013:8) believes that qualitative codes are crucial components of the study story that, when grouped together based on similarity and uniformity (a pattern), actively support the establishment of categories. Therefore, for this study the codes from Atlas.ti™ version 9 were developed into categories and then into themes and subthemes based on their similarity and uniformity. Thereafter, Creswell (2014:139) advocates that the researcher should be able to demonstrate in the report that the interpretation of the research data is reliable and accurate. The following section will discuss the validity, reliability and trustworthiness of the study.

4.6 VALIDITY, RELIABILITY AND TRUSTWORTHINESS

Validity and reliability are the two most significant and fundamental characteristics in determining the success of a study (Mohajan 2017:58). Validity refers to the precision by which the data is accurately interpreted (Noble & Smith 2015:34). To meet the validity requirements of the study, the primary data collected from the semi-structured interviews, which was based on the interview guide, were transcribed for accurate interpretation. According to Kallio et al (2016:20), developing a thorough semi-structured interview guide improves the trustworthiness of qualitative research. Consequently, one of the measures taken by the researcher to improve the trustworthiness of this study was to allow for a thorough review of the interview guide by the supervisors and second coder before it was finalised. Other trustworthiness measures considered will be described later in this subsection.

The availability of rich, sufficient, and well-saturated data determines the reliability of content analysis results; therefore, data collection, analysis, and reporting are all interconnected (Elo, Kääriäinen, Kanste, Pölkki, Utriainen & Kyngäs 2014:8). As per Nowell, Norris, White and Moules (2017:3), there are five factors to be considered for trustworthiness, namely credibility, dependability, confirmability, transferability, and authenticity. The following subsections discuss the factors to be considered for trustworthiness.

a) Credibility

Researchers must ensure that those involved in research are correctly identified and defined. According to Elo et al (2014:2), this is the requirement for establishing credibility. To ensure the credibility for this study, the sample was based firstly on the FMs and RMs with experience and knowledge about ABC adoption considerations and refinery processes for optimal product mix decisions, for the activities they are performing.

b) Dependability

The reliability of data over time and under various conditions is referred to as dependability (Elo et al 2014:4). For this study, the researcher had reviewed recent and relevant literature, as well as seminal works in the identified research field. Furthermore, the sample of the participants was spread across different refineries. The research process and design were explained in detail and the views of the participants were recorded to ensure greater dependability. A participant who was interviewed may, by special request, listen to only their own recorded interview.

c) Conformability

Conformability refers to objectivity and means that the data correctly reflects the information given by the participants, and that the inquirer did not create the interpretations of such data (Elo et al 2014:2). The results must represent the voices of the participants and the circumstances of the investigation, rather than the researcher's biases, motives, or perspectives (Polit & Beck 2012:20). Therefore, for this study, all the semi-structured interviews were recorded with audio recorders and then transcribed to ensure conformability with member checking. Member checking is when the participant is used to check the data's truth value to guarantee that the interpretations from the interviews embody his or her meaning (Creswell 2014:259). Member checking is mainly used for ensuring trustworthiness and accuracy of the qualitative study. Therefore, as previously explained, the transcribed data collected in this study was member checked.

d) Transferability

Transferability refers to the extent whereby the outcomes can be adapted to multiple environments or classifications (Elo et al 2014:2). Therefore, the results of the interviews were compared and contextualised in the literature, leading to transferability. It should be noted that the results of the study were not generalised to other contexts and settings. The results were based on the collected and transcribed data. In addition, the analysis was based on the data coded by the researcher and confirmed by the second coder.

e) Authenticity

Authenticity refers to the extent to which researchers accurately and honestly describe a spectrum of situations (Elo et al 2014:2). Hence, the study's literature review and semi-structured transcribed interviews allowed for different realities to be explored. Ultimately, similar or comparable findings should be obtained by an independent researcher (Noble & Smith 2015:34). Therefore, for this study, the audio-recorded semi-structured interviews with the managers were transcribed, member-checked and then coded by the primary researcher as well as an independent second coder to ensure the authenticity of the data.

This subsection described various measures taken to produce research of high quality. It is, however, also important to take note of the limitations of the research methodology, which will be discussed next.

4.7 LIMITATIONS

An inherent limitation of qualitative research is that it is not statistically representative as is the case with quantitative research (Aspers & Corte 2019:145). Although the sample selection for qualitative research may be biased and have a limited number of participants, the researcher should ensure that a saturation point is reached in data collection (Aspers & Corte 2019:145). Charlesworth and Foëx (2016:151) stated that qualitative research is time consuming as it requires a vast amount of time to undertake data collection and data analysis, which is subjective by nature. As much as there are inherent limitations of qualitative research, it is known for giving an in-depth understanding of a specific problem based on the participants' responses (Creswell 2014:261). Therefore the research problem addressed in this study required an understanding from the participants' knowledge and was not concerned with numerical representivity. Consequently, a qualitative research approach was adopted.

Moreover, the researcher data is limited to what the individual participants said at the time since the primary data for this study was obtained through semi-structured interviews. To manage this limitation, the interview guides were sent in advance to allow participants time to think about responses before the interviews. Hence, the study findings are limited to that context and were therefore not generalised to other contexts and settings.

The interview guides used in the semi-structured interviews had three sections. In the first two sections, participants could choose to answer questions at their own pace before the interview, or during the interview. The participants therefore had the opportunity to take their time and think about the answers they provided, which reduced the pressure on them. This was followed by the third part, which was an audio interview in which the researcher verbally asked the questions to the participants and informed them that they could ask for clarity on the meaning of the questions. However, because they had the questions in advance, the pressure on them was reduced and this limitation was managed.

As much as it is important to consider limitations of research, it is also imperative to consider ethical issues during the formulation of a research plan. The next section will discuss the ethical considerations of this study.

4.8 ETHICAL CONSIDERATIONS

As discussed below, before performing the semi-structured interviews, ethical clearance was acquired from the UNISA College of Accounting Sciences Research Ethics Review Committee (Appendix A). Formal invitations with ethics clearance number 2021-CAS-023 were sent to the 10 prospective participants, and participants signed the participants' information sheets (Appendix B) and consent to participate forms (Appendix C) before the interviews. Also, to ensure privacy and confidentiality, the transcriber and second coder provided confidentiality agreements.

It is critical to ensure the safety of human subjects in all research investigations by following relevant ethical guidelines (Arifin 2018:30). In all stages of a qualitative study, the consideration of ethical concerns is important in order to maintain a balance between the possible risks of research and the benefits (Arifin 2018:30). According to Jahn (2011:225), the researcher should adhere to four basic ethical principles: respect for autonomy, which is a standard practice that requires everyone to respect the views of adults with decision-making ability; beneficence, which is a moral responsibility to act in the best interests of others; and non-maleficence, which is a moral responsibility not to endanger someone else, and an equal distribution of rewards, risks, expenses, and resources is required for justice.

The researcher has complied with the basic ethical principles. Respect was the first principle the researcher adopted hence participation in the study was voluntary, with no undue influence. The participants were provided with a consent form and information documents which informed them that they could withdraw from the research process at any time without fear of victimisation. In addition, measures taken to ensure privacy, confidentiality and protection of information were implemented as the transcriber and second coder signed confidentiality agreements, while the supervisors of the study are bound by the university's confidentiality regulations. To ensure non-maleficence, the study was classified as having low risk based on the university ethics standards and due to COVID-19 risk all interviews were conducted online via Microsoft Teams, as it was the safest and preferred method. Furthermore, in terms of beneficence, the researcher conducted high quality research with the hope that it will benefit the crude oil refinery managers. Lastly, in order to comply with the principle of justice, which refers to the distribution of risk to society, no vulnerable populations were selected. Participants were purposively selected and were allowed to give their views as they have vast experience in the industry. The next section provides the summary of the chapter.

4.9 SUMMARY

This chapter discussed the choice of research approach adopted based on the aim and objectives of this study. The research approach is a method and technique that varies from general assumptions to comprehensive information gathering, assessment and analysis of data. There are three different methodologies, namely quantitative, qualitative, and mixed methods. This study has followed a qualitative research methodology which is used to interpret phenomena according to the meanings that people bring to them.

A paradigm is a common point of view or set of ideas, it is an approach of looking to something. There are four possible research paradigms, namely, radical humanist, radical structuralist, interpretive and functionalist. This study followed the interpretive research paradigm as it interprets the universe at the level of subjective experiences of the participants.

In addition, the research design was discussed in conjunction with the elements of the research methodology, which has five main elements namely, population, sampling, research instrument, data collection and data analysis. The target population of the study consisted of four crude oil refineries which produce petroleum product from crude oil. The main categories of sampling techniques were discussed with the focus on non-probability sampling as it was used in this study. Two crude oil refineries were sampled namely, SAPREF and NATREF.

The different types of interviews which may be used as the instrument for primary data collection in a qualitative study were discussed, namely structured interviews, narrative interviews, and semi-structured interviews. The latter was used in this study with two detailed self-designed interview guides. The interviews were audio-recorded and transcribed, followed by data analysis through thematic codes using Atlas.ti™ version 9 software.

The chapter emphasised the importance of data validity and established the factors of data trustworthiness. There are five factors to be considered for trustworthiness namely: credibility, dependability, confirmability, transferability and authenticity. Thereafter, the limitations of the research methodology were discussed as qualitative research has inherent limitations. As such, the findings of this study are not generalisable as they are limited to the responses from the selected participants.

Lastly, before performing the semi-structured interviews, ethical clearance was acquired from the UNISA College of Accounting Sciences Research Ethics Review Committee, to perform the research. Consent was obtained from the refineries as well as from the participants, through consent forms. Participation in the study was voluntary and the study was performed by the researcher in an ethical manner. The chapter also described the importance of ethical research and how it related to the study at hand. The next chapter will discuss the research analysis and outcomes.

CHAPTER 5: RESEARCH ANALYSIS AND FINDINGS

5.1 INTRODUCTION

In Chapter 4, the research design and methodology were discussed. Qualitative research was proposed for the study, which was described as an interpretative process that highlights the variations from critical voices within the same sample.

This chapter will analyse and interpret the data obtained from the semi-structured interviews with the two groups of refinery managers and relate this to the literature review. The analyses and interpretation of data collected from the semi-structured interviews are used to meet objectives three and four of the study.

Chapter 5 will commence with a discussion on the coding process, followed by an overview of codes and categories synthesised into three themes with their associated subthemes. Thereafter, the findings from the semi-structured interviews will follow. Lastly, this chapter will be concluded with a summary. The following section will discuss the process followed in the coding of the transcripts.

5.2 PROCESS OF CODING

Coding is a word or phrase that summarises a portion of language-based data (Saldaña 2013:3). According to Vogt, Vogt, Gardner and Haeffele (2014:13) a researcher generated pattern that translates qualitative data is a code. For this study, the interview transcripts were used as the language-based data, by the researcher and the second coder. The researcher went through multiple coding cycles in Atlas.ti™ version 9 to understand the coding principle. The first five transcripts' coding was done to understand the principle of coding and determine how the reports with quotes and codes are created. Once the researcher understood the coding principle, the first cycle of coding analysed quotations from the scripts to formulate the high-level codes which met the objectives of the study. The second coding cycle synthesised the analytic work from the first cycle of coding focusing on linking the high-level codes to the detailed quotes to determine the categories and formulate themes.

The transcripts were sent to the second coder without the code book. The second coder followed inductive reasoning to identify the codes, as a trained data interpreter. Inductive coding is when codes are set based on the data itself, in other words, the codes emerge from the data (Miles, Huberman & Saldaña 2013:81). The second coder performed two cycles of data coding using Atlas.ti™ version 9. To code for the first cycle the second coder read the raw data aloud and made sense of its meaning in context. This cycle was mainly at the descriptive level. At this stage, the second coder also assigned prefix codes, but remained cognisant of coding according to sample groups, Refinery manager (RM) and Financial manager (FM), as well as questions. For the second cycle of coding, the second coder refined the codes through a process of focusing on analytical meaning. This includes less detail on coding-to-quotations linkages and more on review-based linking of the coding data to the research questions and the conceptual areas of the study. The second coder therefore revisited the interview guides and formulated two network views. The network views may inform higher order thinking about the meaning of the data.

The researcher developed 58 high-level codes that were not specific to a question number or a specific group of managers. The second coder developed 132 codes, with the question numbers and type of manager used as code prefixes. This allowed for easier identification of which question and interview guide the code comes from. When the researcher compared their codes with that of the second coder, the codes had commonality and represented the same perspective. The researcher held a virtual meeting with the second coder and the study supervisors to clarify all coding issues and reach coding consensus. The following section provides an overview of the codes, categories and table of themes and subthemes.

5.3 OVERVIEW OF CODES, CATEGORIES AND THEMES

Nine categories, listed in Appendix E, were developed from the codes, which were then used to develop the themes and subthemes. According to Saldaña (2013:14), a theme is a phrase or sentence that is an outcome of coding with categorisation, which describes what the unit of data entails (Saldaña 2013:175) and directly relates to the objectives of the study (Saldaña 2013:177). Miles et al (2013:117) stated that themes group and conceptualise clustered data that leads to an improved understanding of a certain phenomenon. Therefore, for this study the themes were clustered, and interpretations of the categories were then formulated into higher-order ideas, with the addition of supporting literature. From the codes and categories, four themes and eight subthemes were formulated which are linked to research objectives 3 and 4. Table 5.1 lists the four themes together with the related subthemes which were developed from the categories and codes.

Table 5.1: Themes and subthemes

Theme	Subtheme
Theme 1 Innovative processes to optimise the refinery product mix	1. Refinery processes to determine product mix 2. Refinery optimisation through technology and human intelligence
Theme 2 Refinery adaptive business practices to counter disruptions	1. Adaptive business practices in the refinery 2. Value chain disruptions in the refinery owing to COVID-19
Theme 3 Actual and regulated costing practices in the refinery	1. Refinery current production cost and cost strategy 2. Price regulation in refinery current production cost
Theme 4 ABC adoption considerations	1. Adoption of ABC for more accurate product cost 2. Challenges and benefits of adopting ABC

Deeper insights derived from the data analysis will be discussed in the next subsection, grouped according to each theme and related subtheme.

5.4 FINDINGS ANALYSIS

The findings analysis mainly focuses on analysing the responses from the RM and FM participants with four themes and related subthemes as indicated in Table 5.1. Themes 1 and 2 relate to objective 3, namely to explore the refinery processes in determining the optimal product mix and effect of COVID-19 in selected South African refineries. Furthermore, themes 3 and 4 relate to objective 4 which is to explore the refinery managers' opinions on the costing currently used and ABC adoption considerations for the selected regulated petroleum products in South Africa. The following subsection discusses theme 1.

5.4.1 Theme 1: Innovative processes to optimise the refinery product mix

This theme focuses on innovative production processes that are currently being used in the refinery to optimise the product mix. There are two subthemes which are linked to theme 1, namely the refinery processes to determine the product mix and refinery optimisation through technology and human intelligence. The following subsections will discuss the related subthemes.

5.4.1.1 Subtheme 1: Refinery processes to determine the product mix

The refinery process to determine the final product mix starts from the planning process which is performed six months in advance. While the RMs agreed that planning for production starts six months in advance, there are changes in the plan until the month of production. One participant, participant E(RM), further explained that the, *"Six-month plan is just a projection.*"

The production plan includes multiple factors to be considered when determining the final product mix, hence RMs were asked in Q4 how the refinery determines high-value petroleum products to produce, specifically the product mix between diesel and petrol. All three RMs had the same view, expressing that the main factors considered during the planning process are refinery configuration, available crude oil, product market demand and the margin of each petroleum product. The configuration of the refinery remains unchanged in all scenarios, but the type of crude oil available varies. Given the regulated BFP, the margin on petroleum products fluctuates as it depends on international market prices, therefore, the final margins are beyond the control of South African refineries.

It is to be noted that 80% of the product mix and margins are fixed once the crude oil purchase is confirmed, as they are determined by the type of crude oils purchased. Hence, the type of crude oil purchased is the main determinant of the product mix. The RMs described the importance of crude oil in determining the product mix by participant G(RM) saying,

"*Depending on which crude oil you purchase you will produce different products,*" and participant E(RM) stating that,

"*Eighty percent of your margin, your product mix, everything is fixed when you purchased the crudes.*"

After taking into consideration all the factors in the planning process, the goal of the refinery planning team is to optimise the crude oil input and product mix which leads to refinery optimisation. While the planning process of analysing different scenarios of expected product mix is done six months in advance, the crude oil purchases are done three months in advance. The RMs agreed, but participant F (RM) further elaborated, "*Three months prior we determine what is the suitable crude that will be processed in that particular month."*

As per the literature, the Canadian Fuels Association (2013:11) stated that the product mix is determined during the planning process. Do (2014:3) further confirmed that the type of crude oil used in the production process determines the product mix. The responses of the RMs therefore supported the literature on the importance of crude oil type to determine the product mix. This means that in order to optimise the product mix, refiners face a daily challenge of deciding which crude oil to purchase in order to optimise the petroleum product mix.

In regard to the product mix between diesel and petrol, market demand and margins of each product are key factors to determine if the refinery should produce more diesel or more petrol. Participants indicated that switching the product mix between diesel and petrol is not an easy process as both products use specific levels of naphtha; impacting each other's production levels. Participant E(RM) confirmed the above by saying,

"To cut petrol from 50% to 20% it will have an impact on diesel."

Participant G(RM) elaborated that the switch may be 2%, taking into consideration the crude oil make-up, as the crude oil molecules that produce different products do not change. Participant G(RM) provided an example by saying,

"If crude oil has 30% diesel, from that specific crude oil up to 32% diesel or maybe 28% diesel may be produced but it cannot produce 60% diesel."

This led to RM Q5, in which RMs were asked how flexible the production process is on changing the production mix output between diesel and petrol. All RMs agreed that there is very limited flexibility on the product mix once the crude oil has been purchased, as it has been indicated that the product mix mainly depends on the refinery configuration and type of crude oil. The RM participants however specified that the product mix may be changed two months before the month of production as the crude oil to be used in production may be changed. Participant E(RM) specified that,

"*The flexibility is for month plus one.*"

Based on the statements from participants the refinery is not very flexible on changing the product mix during the month of production. With participant E(RM) emphasising,

"*It is not possible; it can go on lower if the refinery shut down or in the crisis mode.*"

Therefore, the selected South African refineries are not that flexible to change product mix during the month of production, even though the literature states that there are refineries which are geared to change product mix based on market demand (Canadian Fuels Association 2013:4). The following section will discuss how technology and human intelligence have become part of the refinery optimisation.

5.4.1.2 Subtheme 2: Refinery optimisation through technology and human intelligence

Subtheme 2 will discuss how the refinery uses technology in conjunction with human intelligence to optimise the refinery. The refinery uses a mathematical model known as the linear progression (LP) model to estimate the optimal petroleum product mix. Du Pont (2004:44) revealed that South African refineries use a linear programming model to determine optimal product mix. The participants explained that the LP model uses simultaneous equations which consider all possible crude oil inputs and provides the best expected petroleum product mix the refinery may produce. Based on this explanation, the LP model appears to use the same principles as the linear programming model discussed in sections 2.5.4 and 3.9. There are several scenarios to determine the product mix that optimises the refinery which may be captured in the LP model. All three RMs stated that the LP model is a very important technological tool that is used in the refinery to imitate the refinery configuration, as well as the different petroleum production mixes that the refinery may produce. Participant F(RM) explained the model as,

"*A representation of the refinery in a computer.*"

According to the RMs the LP model is therefore the key technological tool used to optimise the refinery as it provides different scenarios of product mixes, based on the available constraints and crude oil, the demand for the petroleum products and margins of the petroleum product mix to be produced. As the refinery optimisation is deeply rooted in multiple variables and is time-sensitive, the LP model plays an important role to ease the planning process and understand the effect of each decision that may be taken to purchase crude oil, to determine product mix and optimise the refinery. All the production plans for the refinery are captured in the LP model before any decision is taken.

The view from the RMs on the LP model agrees with Fahim et al (2010:255) as they stated that to achieve accurate planning, a refinery may use different mathematical models, such as a linear programming model, to estimate the optimal product mix. Humans operate LP models and refineries; therefore, the refinery optimisation depends on the human adaptiveness and effective usage thereof. Through human intervention, the LP model therefore projects every possible product mix, including scenarios that have never been tested before. One RM, participant F(RM), alluded to the importance of human innovation in seeking solutions that will result in optimisation saying,

"*They think outside of the box.*"

The responses from RMs demonstrate the role played by human intelligence alongside the technological LP model to optimise the refinery. Therefore, it is important to note that the RMs confirmed that the refinery is not merely operated by robots. Human intelligence drives creative adaptation and innovation as RMs deal with a complex refinery production process which considers multiple factors. The following subsection will discuss theme 2 which describes the refinery adaptive business practices to counter disruptions.

5.4.2 Theme 2: Refinery adaptive business practices to counter disruptions

Theme 2 was developed to understand how South African refineries adapt when faced with disruptions. In March 2020, there was a country lockdown which disrupted local value chain operations due to the global COVID-19 pandemic. The petroleum industry value chain was not excluded, with the refinery production process being the part of the value chain that was affected. COVID-19 dynamics therefore challenged the normal ways of operating and forced refineries to develop new ways of operating. This theme discusses the effect of disruptions and changes relating to the COVID-19 effect on refinery operations and the value chain. There are two subthemes, namely adaptive business practices in the refinery and value chain disruptions in the refinery due to COVID-19. The analyses were developed from section C Q7 of the interview guide for RMs.

5.4.2.1 Subtheme 1: Adaptive business practices in the refinery

Adaptation is the key to business survival in changing environments. In order to understand how adaptive the South African refineries are, Q7 for RMs was developed which considered the perceived effect of COVID-19 on the refineries' operational and strategic activities. The RMs had a clear view of the COVID-19 effect: participant F(RM) elaborated on this matter by saying,

"*COVID-19 has posed a challenge to the status quo, resulting in new and creative ways of operating."*

and participant F(RM) added that,

“We were forced to change the mind set and challenge the refinery boundaries.”

In addition, participant E(RM) emphasised the above by saying,

“We had to push the limit which was the first time.”

According to the study participants, the refinery employees had to change the way they used to operate the refinery and be adaptive to the changes brought about by COVID-19. The RMs agreed on the challenge’s refineries faced and realised that in order to survive, they had to adapt to new ways of operating the refinery which had never been used. COVID-19, therefore, forced the refinery employees to operate in an environment they had never operated in while still optimising the refinery. Participant G(RM) stated how they managed to operate the refinery successfully by stating,

“The refinery personnel did miracles as it was the first time in history some of the activities were done.”

RM participants responded that continuous improvement was critical. New ideas were tested, while prioritising the safety of people. The COVID-19 effect forced the change of the refinery profile and economics. The RMs explained that the refinery profile is the different points where the refinery cuts crude oil to determine the final product mix. Participant F(RM) asserted that,

“*The profile of the refinery had to be changed to minimise jet fuel hence crude cuts were changed.*”

The change of the refinery profile was visible to all RMs, with certain RM participants, providing examples. Participant E(RM) said,

"*We had to push the limits, up to 40 cubes per hour where the minimum usually was around 80 to 100 per hour,*" and participant G(RM) said,

"*They managed to divide the jet fuel production by two for the first time in history.*"

Based on the above responses from RMs, it is clear that the refineries were adaptive to new ways of operating, while keeping in mind the importance of refinery optimisation and safety. The adaptation was driven through innovation and human creativity. Through brainstorming and testing different possible scenarios, some of the refinery boundaries were challenged and some of them were relaxed. The RM participant F(RM) even stated that,

"*COVID-19 forced or took the mentality that 30 years ago I used to do these things.*"

The RMs explained that brainstorming sessions became an important part of the refineries' day-to-day activities. Refinery employees had to think differently in a short space of time as the refinery survival was the top priority for each of them. The only thing that was important was to make sure that the refinery continued operating effectively, efficiently and safely. The RMs agreed that it was an inspiring time as it was the first time the team had to operate under the COVID-19 dynamics. Participant E(RM) demonstrated that it was not an easy process by saying,

"*We managed to manoeuvre around the process.*"

Hence, RMs have stated that the challenges brought by COVID-19 had forced the team to come up with new ideas and solutions that were analysed without prejudice and that is how the best value and continuous improvement was achieved. The above responses from RMs emphasise the importance of teamwork and having a proper understanding of the refinery processes. Human creativity plays an important role in making sure that the refinery survives the COVID-19 challenge and adapts to new ways of operating without jeopardising the safety of refinery equipment and employees. Based on the RMs responses, owing to COVID-19 dynamics new ways of operating the refineries have therefore been tested and developed.

As indicated in section 2.3, COVID-19 is wreaking havoc in every country on the planet. The following subtheme will discuss the local refinery value chain disruption due to environmental changes specific to COVID-19.

5.4.2.2 Subtheme 2: *Value chain disruptions in the refinery due to COVID-19*

The RMs clearly understand the value chain disruptions caused by COVID-19 on South African crude oil refinery operations. They stated that the most visible effect was the collapse of the jet fuel market due to travel restrictions, hence the refinery had high levels of jet fuel stock which led to an immediate shutdown of the refinery. As the stock was not being sold to the customers, the storage capacity was not available to continue storing the produced product, hence the refinery had to shut down. Participant E(RM) explained the effect of the jet fuel market collapse in the refinery production process by saying,

"*Jet was just a bottle neck.*"

Participant G(RM) also emphasised this disruption by saying,

"*That was a big knock.*"

The RMs participants shared that the first and immediate effect was the three months shutdown of the refinery. The diesel and petrol markets were also impacted because of the country lockdown. This led to the refinery overflowing with multiple petroleum products which put pressure on the refinery storage capacity. Participant E(RM) emphasised the storage capacity challenge by saying,

"The major bottle neck is our storage capacity."

Although the diesel and petrol markets were depressed for a few months, its market recovered back rapidly to normal levels. As the refinery co-produces petroleum products, it could not change the production plan immediately to produce only diesel and other petroleum products without producing jet fuel.

The second effect was how to deal with the crude oil vessels in South African ports or at sea due to the country lockdown. When the country went into lockdown, the crude oil vessels that were in South African ports had to be discharged via pipe to the specific tanks with immediate effect. Further, if crude oil vessels stayed more than the agreed time at sea, they incurred demurrage costs which are expensive. One RM, participant F(RM), stated that they,

"*Needed the best way of handling the vessels that were on sea.*"

As much as there were new rules of operating, the vessels were discharged to the tanks without jeopardising the equipment and the safety of people.

The third effect was to operate the refinery with the crude oil available, as all crude oil orders were delayed. The RMs stated that there were delays in the sourcing of crude oil, therefore, the refineries had to process the crude oils they had in stock. Owing to the limited crude oil available, various scenarios were analysed based on the different crude oils available to determine which product mix to produce. One RM, participant F(RM), confirmed the above by saying,

“We had to process different crudes oil because that is what we had.”

The fourth effect, which is still affecting the value chain, is the process of testing the members/crew on board for COVID-19 when the vessel arrives with crude oil. If any vessel member tests positive, the vessel does not discharge the crude oil until the members are cleared. Participant G(RM) gave a specific example of the vessel delay,

“*In one vessel members tested positive for COVID-19 and the discharge was delayed by 20 days.*”

The last effect was that refinery employees physically working in the refinery were reduced to a limited number while the other employees worked from home. This was taken as a precaution to prevent the COVID-19 spread or infection. Participant F(RM) explained,

“*We learn to operate a refinery with a smaller number of personnel.”*

The COVID-19 effects are visible in the value chain, but the refinery employees came up with different strategies to make sure the refinery continues operating efficiently and optimally. The following subsection will discuss theme 3 which mainly focuses on actual and regulated costing practices in the refinery.

5.4.3 Theme 3: Actual and regulated costing practices in the refinery

Theme 3 has 2 subthemes, with subtheme 1 being the refinery current production cost and cost strategy and subtheme 2 price regulation in refinery current production cost. These subthemes describe the current refinery costing practices and its costing strategy.

5.4.3.1 Subtheme 1: Refinery current production cost and cost strategy

Subtheme 1 analyses how the refinery currently calculates the petroleum product cost and margin. It focuses on understanding how the indirect costs are identified and allocated to the petroleum products, as well as how margins are calculated.

The FM participants indicated that the refinery petroleum product cost is calculated based on the direct and indirect costs. The direct costs mainly include crude oil cost processed for production, while indirect costs mainly include the costs that are not directly linked to the production process such as labour cost, maintenance cost, and rental cost, amongst others. The four FMs displayed an understanding of indirect cost when answering Section C, FM Q1, which required them to describe the main indirect production costs in the refinery. They all provided identical examples of indirect costs, these being labour and maintenance cost, with participant A(FM) being more specific by saying,

"*Our refinery main indirect production costs are the labour, maintenance as well as the cost of investment which comes through via depreciation and interest.*"

Similarly, Fahim et al (2010:405) described the refinery indirect costs, as mainly including salaries, maintenance cost and depreciation. According to the FMs responses, the indirect costs are monitored and tracked on a monthly basis, with participant C(FM) stating:

"*We receive on a monthly basis what we call a statement from refinery where direct and indirect costs are detailed.*"

The RMs specified some indirect costs as being natural gas, steam, hydrogen, and clean gas cost. On the indirect cost, one RM, participant P(RM), stated that as much as water and electricity are indirect costs, they change depending on the level of production,

"*Indirect cost like electricity may increase when we push the level of production.*"

It was also emphasised that during production, RMs consider the indirect cost that might be incurred by participant G(RM) saying,

"*We do not run the units blind on those indirect cost, we take them into account."*

Therefore, both RMs and FMs have a good understanding of indirect cost and work together to make sure that the costs are kept under control. To determine the materiality of indirect cost in relation to the total petroleum production cost, the FMs were asked in section A, Q2, what percentage of the total refinery production cost represents indirect costs. Two options could be chosen, being equal to or greater than 50% or less than 50%. Three FMs stated that the indirect cost is less than 50% of the total petroleum product cost, while one FM stated that it is equal to or greater than 50%. Despite the lack of consensus on the estimated percentage of indirect costs in relation to the total production costs of the petroleum products, the indication of three of the four participants may point towards the indirect cost being less than 50% of petroleum product cost.

As previously indicated, indirect cost is not directly linked to the production process; hence, it is crucial to understand its cost drivers in order to monitor and control it. As per literature, cost drivers are those elements that may be used to assign the actual costs in line with the activities that drive the costs (Wen-Zheng & Yazid-Abu 2019:2). Cost drivers also monitor and calculate the cost of conducting activities and show the frequency at which the costs increase with the level of activity (Yousif & Yousif 2011:14). From the analyses illustrated in Figure 5.1 if it is possible to identify the cost drivers from the refinery production process. Figure 5.1 was developed from responses to an identical question in Section B Q8 of FMs and Section B Q4 of RMs interview guide.

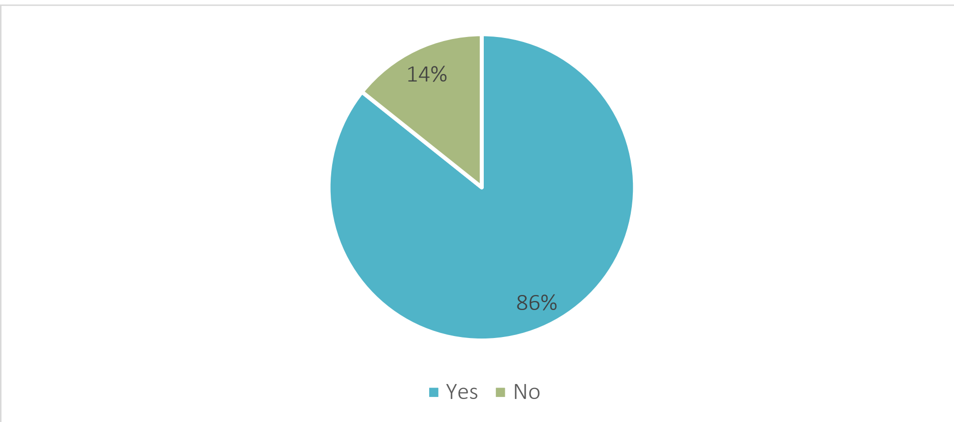


Figure 5.1: Possibility of identifying cost drivers

Figure 5.1 shows that 86% of the participants (three FMs and three RMs), indicated that it is possible to identify indirect cost drivers, while 14% of the participants (one FM) stated that it is impossible to identify drivers of indirect cost. Although one FM stated that it is not possible to identify the cost drivers from the production process, most of the managers are confident that it is possible to do so. Therefore this gives a strong indication that the drivers of indirect cost in the petroleum production process are identifiable.

While almost all of the managers interviewed were confident that the drivers of indirect cost are identifiable, and taking into consideration that refineries have multiple activities, Figure 5.2 shows which activities are perceived to be the highest or lowest cost drivers in the refinery production process. The findings portrayed in Figure 5.2 were based on responses to an identical question in Section B Q9 of the FM and Section B Q5 of the RM interview guide.

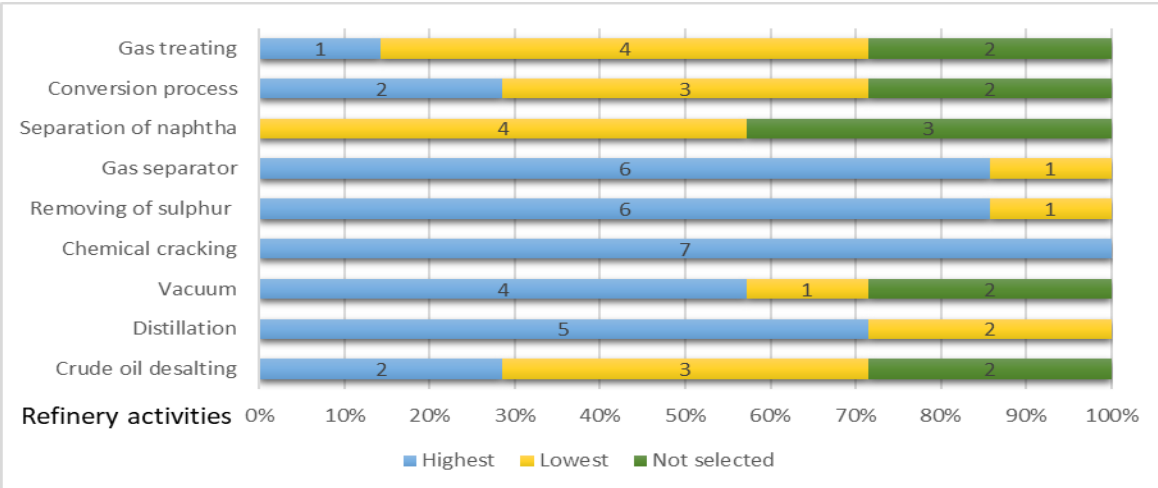


Figure 5.2: Highest and lowest of nine refinery activities as drivers of indirect cost

Figure 5.2 is based on the nine activities selected from the refinery production process to determine which activities are the highest and lowest drivers of indirect cost. In the figure, blue, yellow and green are used to indicate the respective responses of highest, lowest and not selected. The following list summarises the participants' responses:

- All the participants (FMs and RMs) unanimously agreed that chemical cracking activity was the highest driver of indirect cost.
- Almost all participants agreed that the gas separating and removing of sulphur activities can be rated among the highest drivers of indirect cost.
- The majority of participants agreed that the vacuum and distilling activities can also be regarded as high drivers of indirect cost.
- In deciding which activities can be regarded as low drivers of indirect costs, the separation of naphtha and the gas treating activities featured.

- There was a lack of consensus on the lowest drivers of indirect cost possibly because of these activities' decreasing significance in contributing towards cost make-up.

The above indicates that the managers appeared to understand where indirect costs were incurred, and which activities had the highest cost drivers.

Identical questions in Section B Q3 of RMs and FMs asked what was used as the basis to allocate indirect production costs to refined products produced in the refinery. Five options were provided to choose from, namely, machine hours, labour hours, production volumes, BFP, and other. Figure 5.3 analyses what method is currently used to allocate indirect cost in the refinery.

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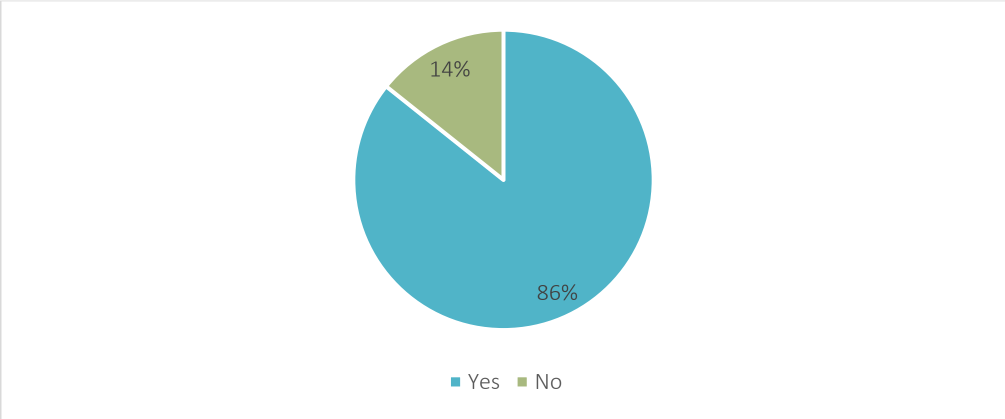

Figure 5.3: Allocation of indirect cost based on production volume allocation ratio

Based on Figure 5.3, six of the seven responses, or 86% of the RMs and FMs, revealed that the method of indirect cost allocation is based on production volume. One RM participant (14%) indicated that the refinery allocates indirect cost using the BFP. Although the current method of allocation of indirect cost was not unanimously agreed upon, a strong impression was given by most participants that South African refineries currently allocate indirect cost based on production volume.

The FMs were asked in Section C Q2 how the cost of refined diesel and petrol is calculated. The FMs described the calculation differently with two of the four stating that the production cost is based on direct costs as well as indirect costs, with indirect costs allocated to petroleum products based on the production volume. The remaining two FMs stated that the production cost in South Africa is based on the BFP. As much as the BFP, was indicated by two FMs, one acknowledged that the actual petroleum product cost is calculated based on direct cost and indirect cost. However, this calculation is not used to reflect the cost price of the petroleum products produced. Participant B(FM) emphasised the calculation of petroleum product cost by stating,

"*We use a model today that consolidates all the costs of raw materials and indirect cost.*"

The RM's emphasised that as much as the BFP is the deemed cost of production, the refinery calculates the actual production cost from direct and indirect costs. The actual indirect cost is then allocated to petroleum products based on the volume ratio. Due to the South African petroleum market being regulated, the refinery uses the BFP as a deemed petroleum product cost.

The product margin is the sum of actual selling price less product cost. Taking into consideration that the refinery uses the BFP as a deemed product cost, FMs were asked in Section C Q4 to describe how the margin of the refined products are calculated. From the FMs' responses it was clear that South African refineries use the international refining margins to determine the petroleum product margins. Two of the participants, participants B(FM) and C(FM), described the calculation as,

"*Both diesel and petrol are benchmarked to the international market margins,*"

and

"*Refinery point of view they refer to product margins as product cracks.*"

Based on the FM participants' responses, the margins are calculated based on the international margins. This means that the margins are not based on the actual selling price less the actual cost of the product. Rustomjee et al (2007:66-67) agreed that the margins of the South African refineries are directly linked to the international refining margins. As per literature, it is to be noted that the calculation is not unique to South African refineries as Chesnes (2015:12) stated that the refinery margins are measured by the international crack spreads which are defined as the difference between the international price of the refined product and the cost of crude oil. The following subtheme will discuss price regulation in the refinery current production cost.

5.4.3.2 Subtheme 2: Price regulation in refinery current production cost

Subtheme 2 describes the effect of price regulation in the refinery production cost. The production cost in the refinery is calculated based on BFP. All seven participants unanimously agreed that the refinery uses the BFP as the deemed product cost, with one of the participants, participant E(RM), affirming this claim by stating,

"*BFP prices are used in the LP model."*

The BFP is published by the Central Energy Fund on a monthly basis for the selected regulated petroleum products based on the international market prices in Singapore, the Arab Gulf and Mediterranean. The RMs and FMs confirmed the above by explaining that,

"*BFP is the equivalent of buying the fuel from international markets,"* by participant B(FM) *and*

"BFP prices is determined by central energy fund," by participant E(RM).

Therefore, by using BFP the refineries assume that the actual product cost in the South African refinery is the same as the product cost from the international refinery. Hence, BFP does not take into consideration the actual refinery production cost in South Africa. Participant A(FM) said that as at today the,

"BFP for finished products are lower than the input costs of your crude oil plus the actual transport cost."

Based on the above, the BFP is used as the deemed product cost of the selected regulated petroleum products, namely diesel and petrol in the refinery. The BFP is therefore the regulated price that the refinery uses to determine the selling price and is not a true reflection of the actual incurred petroleum product cost. The following section will discuss theme 4, which focuses on the ABC adoption considerations.

5.4.4 Theme 4: ABC adoption considerations

In Chapter 3, the current body of knowledge revealed that ABC emerged due to the shortcomings of TC. The ABC allocates indirect product cost based on activities to specific products to reflect the accurate product cost. Theme 4 analyses and interprets the opinions of the FM and RM participants from two South African crude oil refineries on ABC adoption. This theme has two subthemes namely, subtheme 1 focusing on the adoption of ABC for more accurate product cost and subtheme 2 focusing on the ABC challenges and benefits based on the FMs' and RMs' opinions. The following section will discuss subtheme 1.

5.4.4.1 Subtheme 1: Adoption of ABC for more accurate product cost

The FMs were asked in Section C Q5 of the FM interview guide what their understanding of ABC is. The FMs described ABC as a method that analyses the production cost in detail and links the cost to its activities. Participant D(FM)'s explanation of ABC was,

"*You allocate the cost using the cost drivers to the specific product that is produced in the entire refinery chain."*

The FMs' understanding of ABC is in line with the literature, because Drury (2018:267) defined ABC as a system that allocates indirect costs using activities linked to its drivers. The main initiative of ABC is the allocation of indirect cost to products based on activities instead of using an arbitrary volume ratio. An arbitrary allocation may lead to incorrect allocations of indirect costs to different petroleum products. For instance, a high-volume product may be allocated high indirect costs and a low-volume product may be allocated low indirect costs even when a low volume product might actually have incurred high indirect costs. The FMs agreed that ABC could provide better visibility or clarity of the cost allocation and it may assist in calculating more accurate petroleum product cost. Participant D(FM) assured that,

"*Personally ABC is the best way to actually give a proper good cost of product.*"

The FMs stated that in the refinery it takes a different amount of effort to produce different petroleum products, with some being easier to produce than others. Some products require further treatment, which may require additional activities to be added in the production process. These activities have specific indirect costs and may cause additional maintenance requirements of the refinery units. The refinery allocates indirect cost using the production volume ratio, which is arbitrary to all petroleum products, and it does not consider the effect of the additional cost (Figure 5.3). Therefore, ABC may be the answer to the cost analysis and an accurate allocation, as all additional costs may be allocated to the specific product based on its activities. The following section will discuss the benefits and challenges of adopting ABC.

5.4.4.2 Subtheme 2: Benefits and challenges of adopting ABC

Subtheme 2 investigates the perceived benefits and challenges of adopting ABC in the complex refinery production process, while taking into consideration that the refinery produces for the regulated market. Based on the literature discussed in section 3.9, the adoption of ABC may lead to a more accurate allocation of indirect cost based on the activities, which in turn may lead to more accurate petroleum product costing. When the FMs were asked in Section C Q8 to describe the benefits of adopting ABC, all the FM participants unanimously agreed that ABC may determine accurate product cost for selected regulated petroleum products and may be used to optimise the refinery by using costing from ABC to determine the product mix. Participant A(FM) revealed that,

"If we have to adopt ABC all that we are saying is that we will be able to identify the profitability for a greater extent of the finished products."

Based on Section C, Q6 and Q8, FMs were asked to describe two to three benefits and motivations in favour of adopting ABC in South African refineries. The FMs described multiple benefits of adopting ABC in the refineries, which are summarised below:

- ABC may give a true cost of producing petrol or diesel by allocating the indirect cost based on the activities that drive them.
- ABC provides greater clarity on where costs should be allocated.
- ABC reduces cost subsidisation between high- and low-volume products.
- ABC is best used if you want to define your actual profit margin per petroleum product.

- ABC could provide more accurate data for profit margins, as stated by participant C(FM), "*The margin that we are witnessing and observing on the production today it might not be correct, and you have a situation where you have one product subsidising*."
- ABC may improve petroleum product costs analysis.
- ABC could lead to discussions about why the indirect costs of certain activities are higher than others. For example, why the gas treating cost is higher than the cost incurred for the gas separator. Therefore, it may also allow refineries to evaluate the efficiency of production and make improvements.
- ABC may be used to determine selling prices for petroleum products.
- ABC provides more accurate production cost which may be used to inform production decisions that affect the chosen product mix.

The benefits above describe the positive impact perceived by FMs on the adoption of ABC, therefore it is clear that ABC may provide more accurate product costs and improve management decisions in determining the optimal product mix. The FMs had similar perspectives of the benefits of ABC, with participant D(FM) highlighting that,

"From petroleum industries, adopting ABC may lead to identifying main costs, or which production lines are profitable."

As per literature, calculating the products' cost more precisely may lead to cost reduction (Shaban et al 2014:1), and ABC assists businesses to make informed production decisions by delivering more accurate cost data during the complex production process (Quesado & Silva 2021:14). These previous studies therefore agreed with the FM participants on the benefits of ABC.

As much as the benefits of ABC are understood by the FMs, they also stated that there are some challenges to be considered before deciding to adopt ABC. The FM participants expressed that the complexity of the refinery production process is the first major challenge that may affect adoption of ABC in the refinery. Participant C(FM), for example, stated,

"*Even if ABC is adopted with the changes in the refinery activities and product mix, keeping up with ABC requirements may be a challenge*".

Based on FM participants responses the refinery activities change with the expected product mix, therefore, to be able to track the cost to its activities, a sophisticated system to accommodate the complex refinery production processes must be developed. Participant B(FM) explains the complexity by saying,

"It really becomes complex to monitoring in real time and allocate indirect costs."

Participant B(FM) emphasised that the current system is not geared to accommodate ABC by saying,

"It might even require some system development."

Based on Figure 2.2, which presented the crude oil refinery flow diagram and Figure 5.2, which presented nine refinery activities, the refinery has multiple units linked to activities that should be monitored to be able to allocate indirect cost. The FM participants agreed that allocating indirect costs to the different petroleum products based on activities might be challenging, with one FM, participant C(FM), even asking, *“How do you allocate the payroll or even the maintenance during a month to a specific activity?”*

The FMs stated that a very good or well-managed system which will track daily, on an hourly basis, the time people are spending on each activity, is required. The FMs describe the process by participant D(FM) saying,

“It is technically very intensive,” and

participant C(FM) elaborating on the this by saying,

“*If a unit is producing multiple products how do we allocate between those products within the same unit and of course this is something that needs to be maintained every month.*”

The above findings reflect the complex refinery production process challenges to be considered when deciding on whether to adopt ABC according to the FMs perspectives. Therefore, determining the process to track activities linked to the cost drivers and specific product from the complex refinery production process is the key factor to ABC implementation. The second main challenge of adopting ABC according to the participants is the fact that the South African refinery operates in a regulated market. For products like petrol and diesel, it is difficult to adopt a different costing model because the final selling price is regulated, and the petroleum production used is the deemed cost, namely the BFP. Participant B(FM) emphasised the product regulation by saying,

“*After all, it is legislated hence we must follow whatever the government is saying.”*

Furthermore, participant B(FM) continued and became more specific*,*

“ABC in this instance does not help me because it cannot change my behaviour when it comes to setting the selling price.”

Then participant C(FM) elaborated further by saying,

“*The fact that government regulates product prices, the market will not accept a higher price than what the government is regulating.*”

The FMs also stated that even though more accurate petroleum product costs can be determined using ABC, which may be higher than the regulated prices, the refinery will still not be able to transfer that cost to the customers. Therefore, whether the petroleum product cost is calculated using ABC or TC, the refinery results remain the same when it comes to profitability. Certain FMs made the statements below to emphasise that as much as a decision may be taken to adopt ABC, due to the regulated market, the petroleum product margins will not change, for example,

“*It is not that you can get more margins,*” by participant D(FM), and

“*You cannot sell it for the price plus a margin equal to ABC,*” by participant C(FM), and

“*Allocating the cost differently is okay but it does not change the result at the end,*” by participant B(FM).

According to the FMs responses above, ABC adoption has clear benefits for the refinery production process, but there are two main challenges, namely, the complex refinery production process and the fact that the selected petroleum product prices are regulated. The FMs' responses revealed an important concern that has to be taken into consideration before a decision to adopt ABC is considered. The following section will discuss the summary of the chapter.

5.5 SUMMARY

This chapter included an analysis and discussion of the qualitative data that was collected through semi-structured interviews. The researcher and second coder used Atlas.ti™, version 9 to independently create codes. The researcher compared the two sets of codes, established commonality and consensus, and then used the codes to develop four themes and eight subthemes linked to the third and fourth objectives of the study.

Theme 1 with its two subthemes mainly described the innovative processes to optimise the refinery product mix. Two subthemes emerged namely, the refinery process to determine the product mix and the refinery optimisation through technology and human intelligence. Six months before the production month, the LP model is used in the planning process to determine the product mix. Multiple factors are considered before determining the product mix, with the type of crude oil purchased being a key factor. The planned petroleum product mix may be changed a month before production depending on the crude oil available. During the month of production, the refinery has limited flexibility to change because 80% of the product mix is determined by the type of crude oil available to be processed. It may only be changed due to refinery shutdown. Based on the available crude oil, human intelligence combined with the technological LP model is used to analyse the various product mixes to inform optimal product mix decisions.

Theme 2 focused on the refinery adaptive business practices to counter disruptions. This theme has two subthemes which are adaptive business practices and value chain disruptions in the refinery due to the COVID-19 pandemic. In 2020, COVID-19 disrupted the refinery production process. Adaptation is the key to business survival in changing times and the disruption drove the refinery employees to adapt and think creatively. New ideas to optimise the refineries were tested, while prioritising the safety of people. The COVID-19 effect forced the change of the refinery profile and economics. To keep the refinery operating, refinery employees had to adapt to new ways of doing things, like changing the refinery profile where crude oil cuts were changed, and the refinery was run at a very low rate for the first time.

The RMs clearly understand the disruption caused by COVID-19 in the South African refinery operations. There are multiple aspects that disrupted the refinery value chain due to COVID-19. Firstly, the most visible effect was the crash of the jet fuel market which caused the refinery to shut down. Then the country lockdown effect on the refinery value chain with regard to the shortage of crude oil due to delays on vessels at sea and lastly the limited number of employees that were physically working at the refinery.

Theme 3 described the refinery current practices in calculating actual and regulated costing. There are two subthemes namely, refinery current production cost as well as cost strategy and price regulation in refinery current production cost. The cost drivers of indirect cost are identifiable from the refinery production process Actual petroleum product cost is calculated using direct and indirect cost, with indirect cost allocated to petroleum products using the volume produced. As much as the actual cost of product is calculated by the refinery, the refinery uses BFP as a deemed product cost due to the South African petroleum industry price regulation. The BFP is based on international refinery market prices; it assumes that the cost of refining product in the international refinery is equal to the cost of refining petroleum product in South Africa. Therefore, the actual product cost is not equal to the BFP.

Lastly, theme 4 analysed and interpreted the opinions of the FMs and RMs on ABC adoption based on two subthemes namely, adoption of ABC for accurate product cost and the perceived ABC benefits and challenges. As much as there are multiple benefits of adopting ABC in the refinery, there are also two main challenges to be considered before the decision to adopt ABC is taken. The main challenges are the refinery complex production process and that South African crude oil refineries operate in the regulated market. Although South African refineries calculate the actual cost of petroleum product, they use BFP as the deemed cost of petroleum product because crude oil refineries operate in the regulated market. Therefore, changing the indirect cost allocation may not change the margins for petroleum products. The next chapter will provide the summary, conclusions, and recommendations of the study.

CHAPTER 6: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

In Chapter 5, the findings of the study were made based on the thematic analysis of the empirical data that was interpreted and contextualised in relation to the literature. Chapter 6 provides a summary of the study, draws conclusions on the aim and objectives, and makes recommendations.

The chapter commences with a summary of the research study, and a review of the main findings in relation to the study's objectives. This is followed by the conclusion on the aim of the research study. Thereafter, the limitations of the study are provided. Finally, the recommendations based on the study's findings are presented, along with suggestions for future research.

6.2 SUMMARY OF THE RESEARCH

In Section 1.2, the importance of the petroleum industry to the income and GDP of countries was explained. Because South Africa has small crude oil reserves, the petroleum industry in South Africa focuses on the downstream segment of the three segments in the petroleum value chain. Despite the South African petroleum industry being operated by companies, the DOE regulates the pricing of certain petroleum products based on import parity, known as the BFP, as if there were no refineries in South Africa. Even though refineries calculate indirect and direct cost, the petroleum product cost is based on BFP which means that the total cost of regulated petroleum products is a deemed cost. Therefore, refineries product mix decisions may be based on a deemed cost that does not reflect the actual optimisation value from the local refineries' best product mix.

Section 1.2 established that the ABC system emerged as an alternative costing system due to shortcomings of the TC. The ABC principle of identifying activities and allocating them to cost drivers provides organisations with a better understanding of cost causation, which may lead to more accurate product costs to inform subsequent product mix decisions. Although studies from developing and developed countries have shown that ABC may calculate more accurate product cost, there are limited ABC studies in the private sector, manufacturing-, petroleum-industry and regulated industries in South Africa. It was argued that by adopting ABC the South African crude oil refineries may be able to determine more accurate product costs, which may assist them in making more informed optimal product mix decisions.

The aim of the study was therefore to explore the managers' opinions on ABC adoption considerations and refinery processes in order to inform optimal product mix decisions of selected regulated petroleum products in South Africa. The literature review and empirical research study were used to meet the four research objectives and thus achieve the research aim. The empirical research was conducted using seven semi-structured interviews with participants from two selected South African crude oil refineries. Two interview guides were specifically developed for the Financial managers (FMs) and Refinery managers (RMs), to explore empirical objectives 3 and 4, respectively. The following section will discuss the main outcomes of the research study.

6.3 MAIN OUTCOMES OF THE RESEARCH OBJECTIVES

This section will discuss the findings in respect of the study objectives and how the objectives were met to achieve the aim of the study. The following section will discuss the first objective main findings.

6.3.1 Objective 1: Review of the petroleum refinery value chain, considering the deemed cost of selected regulated products in South Africa

Objective 1 was established to review how the petroleum crude oil refinery value chain operates, and how refineries calculate the petroleum product costs of selected regulated products in South Africa. This contextual background of the study was based on a combination of existing scholarly literature and international and local grey sources, which included industry documents. The literature and grey source were consulted to describe the background and the GDP contribution of the petroleum industry in countries.

The petroleum industry is a powerhouse of a country's economy and the value chain has three segments. The upstream segment, also known as E&P, focuses on the search, exploration and extraction of crude oil. The midstream segment is the link between the crude oil exploration and crude oil processing facilities as it specialises in the transportation of crude oil from where it is extracted to the refineries. The last segment is downstream and includes the refining of crude oil into different petroleum products, as well as the marketing and distribution of the refined petroleum products to the end customer. As established from the literature, South Africa has limited crude oil and therefore, operates mainly in the downstream segment of the petroleum industry value chain.

Before 1954, South Africa imported all their refined petroleum products from European and American refineries. In 1954 the first South African crude oil refinery, ENREF, was built in Durban by Mobil; in 1963, the second one, SAPREF, was built. CALREF was commissioned in 1966 near the coast in Cape Town. Lastly in 1971, Sasol Mining (Pty) Ltd and Total South Africa formed a joint venture which built and operated NATREF in Sasolburg. South Africa has four crude oil refineries and the industry's contribution to the country's GDP is visible.

There are five types of refineries ranging from basic refineries such as topping and hydro skimming refineries, to semi advanced refineries such as cracking refineries, which can produce petrol or diesel. Advanced refineries include coking and full-conversion refineries which produce both diesel and petrol. South Africa has four crude oil refineries with one being a full-conversion refinery and the others cracking refineries. SAPREF has the largest crude oil throughput of 180 000 bbl/d compared to NATREF which has 108 000bbl/d. NATREF is, however, a full-conversion refinery with advanced technology as it has additional units such as hydrocracking and catalytic cracking which make it easy to refine heavy crude oil effectively. NATREF therefore has the ability to produce a higher proportion of high value petroleum products such as diesel and petrol versus by-products.

There are various types of crude oils which are divided into four categories based on quality, namely light crude oil, heavy crude oil, sour crude oil and sweet crude oil. Sweet and light crude oils have higher costs than the heavy and sour crude oils. To determine the value of crude oil, four different reference prices are used, namely, Brent blend is used as a reference for the North Sea region, Dubai-Oman for the Middle East sour crude oil, Tapis for East Asia light crude oil and WTI is used for American high quality sweet, light crude oil. The reference price therefore differs per region and category of crude oil. South Africa mainly uses Brent as a reference for crude oil. All types of crude oils are processed through three phases of the refinery namely the separation phase, the conversion phase and the treatment phase as shown in Figure 2.2. Depending on the type of crude oil purchased and the demand for petroleum products, a different petroleum product mix may be produced. The refinery may be by choosing the right type of crude oil to determine the optimal product mix based on the margins and product demand.

A refinery may process different types of crude oils, which have different values, to produce specific petroleum products. The deemed product cost per unit remains the same as South African refineries use BFP as the deemed product cost per unit. BFP is the international product cost plus importation and transport cost to move the product to South African ports, as if they are not locally produced. The international product costs are based on the weighted petroleum products costs from the refining centres in the Mediterranean area, the Arab Gulf and Singapore, plus the related transportation cost to South Africa.

While the BFP is used as the deemed product cost, South African refineries have an actual operating cost incurred due to the refinery operation. The actual cost should be considered when calculating the product cost. The refinery's operating costs are divided into two categories: direct and indirect costs. The direct cost mainly includes crude oil cost processed for production and other costs directly linked to the production process which increases or decreases with the produced volumes. The indirect costs include the costs that are not directly linked to production process.

The profitability of a South African refinery is directly linked to the international refining margins, known as the crack spread, which is linked to the crude oil price and petroleum products' price in the international market. The crude oil price fluctuation affects the relationship between refining margins and the BFP. One of the objectives of the BFP is to ensure that a refinery earns refining margins to cover its operating cost and becomes profitable. Currently, the actual refinery margin is calculated holistically, where the indirect cost is shown as the total value or allocated using a volume produced to determine the margin of each regulated petroleum product. Objective 1 was therefore met in that the crude oil refinery value chain was described and the deemed cost of selected regulated products in South Africa was explained. The following subsection will discuss objective 2.

6.3.2 Objective 2: Investigate the concepts generally associated with an ABC system, considering ABC through the lens of optimisation theory

This objective was developed to better understand the ABC concepts and principles based on nationally and internationally published academic, professional and grey literature, and analysis of the data from websites. The ABC has been used to complement TC since the 1980s, when it was presented by Robin Cooper and Robert Kaplan. It has surfaced as a system that enables more effective indirect cost allocation with its main objective to improve product cost accuracy. Its primary goal is to provide a realistic and precise indirect cost allocation and a reasonable product profitability analysis utilising various cost drivers associated with non-volume and volume-based activities to allocate indirect costs.

Cost information is used by managers for inventory valuation, to make cost-related decisions and for performance valuation. Therefore, managers need to know the costing systems that may give them more accurate and relevant costing. Based on the literature, ABC and TC are the two-costing systems which allocate the indirect cost to cost objects.

TC allocates indirect cost arbitrary to product based on volumes or hours which may lead to product cost distortion.

The ABC system emerged from an increasing lack of relevance in TC and as an innovative management accounting system. ABC offers a reasonable and precise indirect cost allocation based on activities, as well as a fair product profitability evaluation. Section 3.4.1 describes the advantages of ABC, which include that it uses real cost activities that improve operational efficiency, ABC provides accurate product cost, and delivers more realistic product costs in an advanced manufacturing environment where indirect cost is a large proportion of the total costs. Section 3.4.2 describes the ABC disadvantages which may include that the ABC system has multiple cost pools and different cost drivers which may be difficult to use compared to TC, it is more expensive to operate the ABC system than the TC system, and the management decision process may take time due to the complexity of the ABC system. According to the literature there are several factors to be considered before implementing ABC to limit the risk of failure. All divisions in the company should be involved from the design stage to minimise the risk of ABC implementation failure. ABC design may appear complicated, but it is simplified if the company understands the origins of its costs. There are four steps to be followed to ensure the successful design and implementation of ABC, namely: identifying activities, assigning resource costs to activities, selecting activity cost drivers and cost objects, and assigning costs of activities to products. ABC systems can be established with fewer obstacles if each stage is completed correctly because the steps are all interdependent. Six key success points of ABC implementation were discussed in section 3.7. namely top management support, non-accounting ownership, adequate resources, links to performance evaluation, ABC system training and ABC being linked to quality initiatives.

The benefits of ABC have been highlighted, with particular emphasis on how ABC assists managers in identifying the source of costs when analysing activities, leading to the elimination of non-value activities and the determination of more accurate product costs. Managers can make better decisions with more accurate product cost information provided by ABC. There are numerous sectors or industries from multiple countries that have effectively implemented ABC, and the sourced literature has shown the benefits of ABC with quantitative and qualitative studies, however the current body of literature is scant regarding ABC adoption by crude oil refineries. This aspect was therefore further explored as part of the empirical field work of the study to address objective 4.

Optimisation is central to deciding between two or more activities, whether in real life or business activities. Optimisation theory may improve the refinery planning production process by determining the optimal economic product mix. Therefore, ABC, through the lens of optimisation theory, may be used to determine the production process activities, calculate the product cost, and review the feasibility of producing each product. Based on the literature and scholarly journal articles to understand the concept of ABC, objective 2 of this study was met. The following section will discuss objective 3.

6.3.3 Objective 3: Explore the refinery processes in determining the optimal product mix and effect of COVID-19 in selected South African refineries

Objective 3 empirically explored the refinery processes in determining the optimal product mix and effect of COVID-19 in selected South African refineries. The refinery process for determining the final product mix begins with a six-month planning process that uses the LP model to assess various product mixes. The LP model determines the optimal forecasted petroleum product mix based on multiple scenarios using simultaneous equations that consider all feasible crude oil inputs, constraints, product costs, and margins. Humans operate the LP model and refineries; hence refinery optimisation and efficient LP model usage are dependent on human adaptability and effectiveness. No matter how much technology and models the refinery may use for informing optimal product mix decisions, human intervention is always needed.

To select the product mix, the plan varies as it considers a variety of factors in order to establish the final product mix. The most important factors to consider throughout the planning process are the refinery configuration, available type of crude oil purchased, product market demand, and each petroleum product's margin. Thus, the type of crude oil available varies depending on the type of crude oil purchased, the margin of petroleum products fluctuates based on international margins changes, the demand for each petroleum product may change and refinery configurations change depending on the product mix. This variation may change the optimal product mix according to the scenario presented.

While the planning process takes place six months ahead of time, there is a limited flexibility on the product mix changes once the crude oil has been purchased. The crude oil purchases are made three months ahead of time, allowing for the fact that it is imported by sea from other countries. It is also important to note that once the decision to purchase a specific crude oil is made 80% of the product mix and margins are already set. As a result, the type of crude oil is the most important factor in determining the product mix and this indicates the refinery configuration. The product mix to be produced may be changed two months before the month of production, or due to refinery shutdown. Therefore, even if the margins and product demand change during the month of production the product mix cannot be changed with immediate effect.

Disruptions have challenged the refinery to change some of the processes used to determine product mix. For example, when COVID-19 disrupted the refinery production process, and secondly, the crash of the jet fuel market due to a country lockdown. Furthermore, the slow movement of petrol and diesel led to the refinery shutting down for almost three months. The refinery profile had to be changed to minimise jet fuel production, which was driven by changing the crude oil cuts. It was the first time that this was done in the refineries and RM participants are of the opinion that refinery employees performed at exceptionally high levels to achieve this. In addition, to continue optimising the refinery, the LP model in conjunction with human intervention played a crucial role as it was used to test multiple possible scenarios through brainstorming sessions. Through human intervention, the LP model tested every possible product mix, including scenarios that have never previously been tested to determine the optimal product mix in order to make a decision to optimise the refinery.

With COVID-19, the refinery had to adapt to a new way of operating. The mindset of the refinery employees had to shift for it to survive. The first important challenge was to take care of the refinery employees to comply with the COVID-19 guidelines, hence, they started operating with a smaller number of personnel. The workforce was divided into smaller groups while still operating the refinery effectively. New ideas were continuously tested. Innovative human intervention played an important role in the adaptive strategy and ensuring that the refineries fully adapt to new operating conditions. Participants stated that to survive, they had to work miracles by being creative, adapting their operating practices and pushing their limits on what the refinery may achieve, for example, running the refinery at a very low level to limit jet fuel production. The participants' responses explained the refinery process they follow to determine the optimal product mix including during the COVID-19 pandemic disruption. Therefore, objective 3 was met empirically through participants' responses that have been placed in context with the literature. The following section will discuss objective 4.

6.3.4 Objective 4: Explore the refinery managers' opinions on the cost and ABC adoption considerations for the selected regulated petroleum products in South Africa

The participants stated that the direct and indirect costs of refinery petroleum products are calculated and that indirect costs are currently allocated to products based on volume produced. This may lead to cost subsidisation as high-volume products are allocated high indirect cost while low volume products are allocated low indirect cost, even if the low volume products have additional activities which incurred high indirect cost. The FMs agreed that ABC could provide better visibility or transparency of the cost allocation and it may assist in calculating more accurately the petroleum product cost.

It was established that the indirect costs are identifiable from the different refinery activities. Even though the indirect cost appears to be less than 50% of the petroleum product cost it affects the final cost per product. The RM and FM participants were familiar with an ABC system as they were able to clearly explain ABC principles. They indicated that ABC can be used to identify indirect costs and the related activities that drive these costs. Additionally, ABC allocates indirect costs based on activities rather than assigning indirect costs on a volume-base across all products. The activities and cost drivers are identified from the petroleum product production process. Therefore, ABC may be used to allocate indirect cost using activities. This allocation may lead to more accurate product cost for each petroleum product produced, especially the selected regulated petroleum products such as diesel and petrol. The accurate cost could then be used to inform subsequent product mix decisions, thereby making the refinery more economical.

The profitability of South African crude oil refinery operations is directly tied to international refining margins. Nevertheless, international petroleum product market prices do not cover all costs associated with producing petroleum products from South African refineries. Furthermore, the actual total petroleum product cost is not passed on in the regulated selling price as it is based on the BFP, a deemed cost. According to the participants, the BFP does not provide accurate profitability and costs of regulated petroleum products. The FM participants stated that ABC may provide more accurate product costing for regulated petroleum products that may improve the strategic decision making to determine product mix. The strategic decision may lead to the improved profitability of the refinery, but it will not change the selling price of a regulated petroleum product such as petrol and diesel. Despite the potential benefits, in the FMs opinion, ABC adoption in refineries is highly unlikely due to the complex production process and regulated market as ABC may not be useful if it is used in conjunction with BFP. Using ABC or TC does not change the regulated petroleum product margins. The ABC system may be used to measure the actual performance of the refinery based on the actual product cost and more accurate indirect cost allocation to assist managers to make economic decisions and refinery optimisation.

The benefits of ABC are noted in the selected South African refineries. However, the complex refinery process and the factors that drive deemed cost are the challenges which may negate the adoption of ABC. These challenges should be considered before the decision to adopt ABC is taken. Objective 4 of the study is met empirically through participant responses that have been contextualised to the literature.

6.4 CONCLUSION

The aim of this study was to explore the managers' opinions on ABC adoption considerations and refinery processes to subsequently inform optimal product mix decisions of selected regulated petroleum products in South Africa. While the participants acknowledged the merits of ABC and would support its adoption, they indicated that it would serve no purpose in the current regulated environment. Thus, the complex refinery production process and the regulated market are the main challenges to be considered before deciding to adopt ABC. As indicated in sections 6.3.1 to 6.3.4, each of the objectives of the study were met, therefore the aim of the study was achieved.

This study has shown the benefits of ABC when used to calculate more accurate petroleum product cost for regulated products such as diesel and petrol. This cost may be used to optimise the refinery. The ABC system may not be used to change margins, but it may improve product mix decisions which may lead to the refinery being more economical. The two groups of managers which are in strategic positions in the refinery have reinforced each other's viewpoints as they have a common goal for the refinery to be economical, innovative, and effective. Hence, they accept the benefits of ABC by agreeing that the system has several benefits which may drive the refinery to be more economical. The view to use ABC is not far-fetched, but the way the industry calculates its cost of regulated petroleum products must be considered. The industry may consider ABC as a system to calculate the petroleum product cost if the current method of calculating the South African petroleum cost based on BFP is changed.

6.5 LIMITATIONS OF THE RESEARCH

When assessing the findings of this study, the limitations should be kept in mind. On the other hand, the limitations provide opportunities for further research.

- The focus of the study was limited to two South African crude oil refineries; therefore, the findings are limited to the opinions of the RMs and FMs from the two refineries. It should be noted that these managers hold strategic roles in the refinery operations.
- The study followed a qualitative research approach, which was limited to seven semi-structured interviews with participants who have experience in the industry. It should, however, be noted that after the sixth interview, data saturation was reached.

Despite these limitations, this study provided new insights related to refinery processes and ABC adoption for optimal product mix decisions in selected South African crude oil refineries.

6.6 RECOMMENDATIONS

The empirical findings demonstrated that crude oil refineries can identify indirect cost drivers and their associated activities. Furthermore, they may adjust the product mix one month before the month of production. It is however suggested that crude oil refineries investigate the following aspects:

- Determine if the operational changes brought by COVID-19 in the crude oil refinery value chain are sustainable to improve the refinery optimisation, especially on changing the product mix during the month of production.
- The importance of innovation and being adaptive with disruptions such as the COVID-19 pandemic in the crude oil refineries.
- Taking into consideration that the BFP is being investigated, if the regulatory system is abolished, considering the adoption of ABC for more accurate product costs to subsequently inform product mix decisions.

The following section will describe the suggested future research.

6.7 SUGGESTIONS FOR FUTURE RESEARCH

The empirical findings and literature highlighted the perceived benefits and challenges of ABC, as well as how ABC may enable crude oil refineries to compute more accurate petroleum product costs for selected regulated petroleum products, allowing them to make better decisions about product mix. In this study, the precise relationship between ABC and the regulated industry was not established. In addition, the reason why the operating costs from international crude oil refineries may differ were not established. As a result, the following future research studies are suggested:

- A study of the relationship between ABC and price regulation, as well as how ABC may impact the optimisation of the crude oil refinery value chain.
- Taking into consideration the regulated petroleum price calculation in South African crude oil refineries, a detailed analysis of why the operating cost of South African crude oil refineries may differ with international crude oil refineries of the same size and type.

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APPENDIX A: ETHICAL CLEARANCE

UNISA university of south africa

UNISA COLLEGE OF ACCOUNTING SCIENCES RESEARCH ETHICS REVIEW COMMITTEE

Date: 13 May 2021

ERC Reference # : 2021_CAS_023
Name : S Hlongwane
Student no: 43503373

Dear MS S Hlongwane,

Decision: Ethics Approval from 13 May 2021 to 12 May 2024

Researcher(s): Ms Sanelisiwe Hlongwane (sane.makhaza@total.co.za)
Supervisor(s): Prof Leoni Julyan (Julyal@unisa.ac.za)
Ms Yolande Reyneke (reyney@unisa.ac.za)

Working title of research: **Exploring activity-based costing in the refineries of the South African petroleum industry value chain**

Qualification: MPhil and Non-degree

Thank you for the application for research ethics clearance by the Unisa College of Accounting Sciences Research Ethics Review Committee for the above mentioned research. **Ethics approval is granted for data collection through interviews.** The certificate is valid for the period **13 May 2021 to 12 May 2024.**

*The **low risk application** was **approved** by the CAS RERC on **11 May 2021** in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the CAS RERC.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.

4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
7. No fieldwork activities may continue after the expiry date **(12 May 2024)**. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

*The reference number **2021_CAS_023** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Signature : **Prof Lourens Erasmus**

Chair of CAS RERC

E-mail: erasmlj1@unisa.ac.za
Tel: (012) 429-8844

Signature : **Dr Chisinga Chikutuma**

Acting head: Office for Graduate Studies and Research
By delegation from the Executive Dean: College of Accounting Sciences

E-mail: chikucn@unisa.ac.za
Tel: (012) 429-3401

APPENDIX B: PARTICIPANTS INFORMATION SHEET

Ethics clearance reference number: 2021_CAS_023

28 May 2021

Title: Exploring activity-based costing in the refineries of the South African petroleum industry value chain

Dear Prospective Participant

I, Sanelisiwe Peacefull Makhaza, am doing research with Prof Leoni Julyan, an Associate Professor in the Department of Management Accounting, towards a Master of Philosophy in Accounting Sciences at the University of South Africa. I have bursary funding from the University of South Africa owing to having insufficient funds for my studies. We are inviting you to participate in a study entitled: Exploring activity-based costing in the refineries of the South African petroleum industry value chain.

WHAT IS THE PURPOSE OF THE STUDY?

This study is expected to collect important information that may benefit South Africa refineries by exploring the suitability of activity-based costing for accurate product costing, focused on two petroleum products, namely diesel and petrol, that could later inform product mix decisions. Practically, the information from the research will be intended for the management of the petroleum companies so that they can ascertain the costs of the regulated products more accurately, which could later inform product mix decisions. Theoretically, this research will reduce the gap in the ABC literature in developing countries in Africa, for regulated industries, and the petroleum industry.

WHY AM I BEING INVITED TO PARTICIPATE?

The study mainly focuses on two crude oil refineries in South Africa, namely SAPREF and NATREF. SAPREF is the largest crude oil refinery in South Africa, and it will provide an overview of the refinery product costing in a coastal context. NATREF is an advanced refinery with a steam cracker unit in South Africa and it will provide an overview of product costing inland. The reason you are invited is because you have the requisite knowledge of the crude refinery strategic and operational activities or the petroleum product costing in the refinery.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

The study involves audio recording, semi-structured interviews, either face-to-face, or online via Skype or Microsoft Teams. The questions will cover two parts of the refinery namely, Refinery Operation Optimisation and the petroleum product costing. It will explore the opinions of managers on the adoption of an ABC system for more accurate costing of the selected regulated petroleum products. In semi-structured interviews, an Interview Guide provides basic guidelines, however, other questions may be asked as the discussion evolves. The interview should take around 45 minutes per participant.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Being in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

According to the researcher, ABC is not a well-researched topic in South African literature and there are a small number of studies. In this regard your participation will enable the researcher to complete her research project and provide valuable insight on the dynamics of ABC in South Africa and specifically for the regulated petroleum industry.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

The interview may be scheduled during working hours which might be inconvenient to you. The researcher endeavours to be as flexible as possible in terms of interview dates and times and to provide you with as much notice as would be reasonable. Another possible risk would be unforeseen circumstances of network interruptions or where your presence or action at work is immediately required during this interview session. In this instance the interview will be postponed to a later date. To mitigate this potential risk, the interview will be prearranged either in your office or online via Microsoft Teams or Skype.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

Your name and that of your company will not be recorded anywhere in the study, and no one will be able to connect you to the answers you provide. Your answers will be given a fictitious code number, or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings. Your anonymous answers may be reviewed by people, either those performing a task, such as a transcriber and second coder, and those responsible for making sure that the research is done properly, including the supervisors and members of the Research Ethics Committee.

Otherwise, records that identify you will be available only to the researcher, unless you give permission for other people to see the records. Your anonymous data may be used for other purposes, e.g. a research report, journal article, conference presentation, etc. A report of the study may be submitted for publication, but individual companies and participants will not be identifiable in such a report. The participants' views will not be identified as an opinion related to a refinery or a company that the person is involved with.

HOW WILL THE RESEARCHER PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked filing cabinet at home for future research or academic purposes; electronic information will be stored on a password-protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval, if applicable. Information will be destroyed by shredding hard copies and reformatting of electronic media after the five-year period has expired.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

You will not be entitled to any payment or incentive for participating in this study.

HAS THE STUDY RECEIVED ETHICS APPROVAL?

This study has received written approval from the UNISA College of Accounting Sciences Research Ethics Review Committee. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings or should you require any further information or want to contact the researcher about any aspect of this study, please contact Sanelisiwe Makhaza (Hlongwane) on 082 377 6479 or 43503373@mylife.unisa.ac.za. The findings are accessible for five years. Should you have concerns about the way in which the research has been conducted, you may contact Prof L Julyan, 012 429 4821 or email julyal@unisa.ac.za.

Thank you for taking time to read this information sheet and for participating in this study.

Yours sincerely

S.P Makhaza
MPhil, student number: 43503373
University of South Africa

APPENDIX C: PARTICIPANTS CONSENT FORM

CONSENT TO PARTICIPATE IN THIS STUDY

I, __________________ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read, or had explained to me and understood the study as explained in the information sheet. I have had sufficient opportunity to ask questions and I am prepared to participate in the study. I understand that my participation is voluntary and that I am free to withdraw at any time without penalty.

I agree to the recording of the interview.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname: …………………………………………… (please print)

Participant Signature……………………………………………____Date…………………

Researcher's Name & Surname: Sanelisiwe Peacefull Makhaza

Researcher's signature……………………………………………___Date…………………

APPENDIX D: INTERVIEW GUIDES (FMs & RMs)

D.1 INTERVIEW GUIDE FMs

The interview guide will assist in completing a Master of Philosophy in Accounting Sciences at the University of South Africa. The researcher conducts qualitative research in order to explore if the adoption of ABC by South African refineries could provide more accurate product costs for the two selected regulated petroleum products produced. Semi-structured interviews are being used by the researcher.

The participant may complete Sections A and B prior to the interview. Section C will consist of questions that the researcher will pose to each participant, requiring a verbal answer.

Section A: Demographic Information

Job title: ___________________________________

Years of experience: ___________________________________

Section B: Questions to select the appropriate option

1. Is the refinery currently identifying the indirect cost portion of the total production cost?

Yes	
No	

2. If ‘Yes’ in question 1, what percentage of the total refinery production cost represents indirect costs?

Equal to or greater than 50%	
Less than 50%	

3. What is used as the basis to allocate indirect production costs to refined products produced in the refinery?

	Yes	**No**
Machine hours		
Labour hours		
Production volumes		
BFP		
Other		

4. Is the basic fuel price (BFP) of regulated products used as the deemed production cost in the refinery?

Yes	
No	

5. Does the current refinery product costing method provide accurate product costing information per refined product?

Yes	
No	

6. Have you practically applied activity-based costing (ABC) in any product costing in the refinery?

Yes	
No	

7. If ‘Yes’ to question 6, are indirect costs linked to the activities easily identifiable in the refinery production process?

Yes	
No	

8. In the refinery, is it possible to identify drivers of indirect cost?

Yes	
No	

9. Of the refinery production activities below, in each column, tick the four activities that are the highest and lowest regarding being drivers of indirect cost (fixed cost).

Activities	**Highest**	**Lowest**
Crude oil desalting		
Distillation		
Vacuum		
Chemical cracking		
Removing of sulphur		
Gas separator		
Separation of naphtha		
Conversion process		
Gas treating		

Section C: Costing system used by the refinery and an activity-based costing (ABC) system – Opinions of Refinery Finance managers

Questions 1 to 4 relate to the costing system used by the refinery, whereas Questions 5 to 9 to the adoption of ABC for more accurate product costing calculations for diesel and petrol.

1. Describe the main indirect production costs in the refinery?
2. How is the cost of refined diesel and petrol calculated?
3. How is the indirect production cost (fixed cost) of the refinery allocated to the refined petroleum products?
4. Please describe how the profitability of the refined products are calculated?
5. What is your understanding of ABC?
6. In your opinion, describe 2-3 motivations in favour of the refinery management adopting ABC?

7. In your opinion, describe 2-3 challenges of adopting ABC in South African refineries?
8. In your opinion, may you suggest 2-3 benefits of adopting ABC in South African refineries?
9. How would the adoption of ABC change the indirect production cost (fixed cost) allocation in the refinery compared to the current process of allocating the indirect cost?

D.2 INTERVIEW GUIDE RMs

The interview guide will assist in completing a Master of Philosophy in Accounting Sciences at the University of South Africa. The researcher conducts qualitative research in order to explore if the adoption of ABC by South African refineries could provide more accurate product costs for the two selected regulated petroleum products produced. Semi-structured interviews are being used by the researcher.

The participant may complete Sections A and B prior to the interview. Section C will consist of questions that the researcher will pose to each participant, requiring a verbal answer.

Section A: Demographic Information

Job title: ________________________________

Years of experience: ________________________________

Section B: Questions to choose appropriate option

10. Is there a model to determine the product mix of the refinery?

Yes	
No	

11. If 'Yes' in question 1, what is the base of the cost used in the model to determine the product mix?

BFP	
Actual production cost	

12. What is used as the basis to allocate indirect production costs (production fixed cost) to refined products produced in the refinery?

	Yes	**No**
Machine hours		
Labour hours		
Production volumes		
BFP		
Other		

13. In the refinery, is it possible to identify drivers of indirect cost?

Yes	
No	

14. Of the refinery production activities below, in each column, tick the four activities that are the highest and lowest regarding being cost drivers of indirect cost (fixed cost).

Activities	Highest	Lowest
Crude oil desalting		
Distillation		
Vacuum		
Chemical cracking		
Removing of sulphur		
Gas separator		
Separation of naphtha		
Conversion process		
Gas treating		

Section C: Questions on Refinery Optimisation process

1. Within current legislation, how does the refinery strategically determine its cost model?
2. In the light of this strategy, what translates into the main strategic and indirect production costs of the refinery?
3. Are any trade-offs made in terms of costing in this way in relation to more innovative ways of costing (e.g. ABC)?
4. How does the refinery determine which high-value petroleum products to produce, specifically the product mix between diesel and petrol?
5. How flexible is the production process on changing the production mix output between diesel and petrol?
6. In terms of the refinery value chain, and based on the production optimisation of a value chain, what do you think the refineries should do, or do differently, to be able to produce the optimum product mix to deliver the best value for the industry?
7. What effect has Covid-19 had on the refineries' operational and strategic activities?

APPENDIX E: CATEGORIES AND MAIN CODES

Categories	MAIN CODES
Covid impact	Q3_RM_cost projections affected by Covid-19 Q4_RM_Covid-19 impelled intelligent adaptions Q5_RM_Covid-19 impelled intelligent adaptions Q7_RM_Covid_change in refinery configurations and economics Q7_RM_Covid_conscious of care and safety of colleagues Q7_RM_Covid_innovation driven through HUMAN creative adaptation Q7_RM_Covid_new product innovation drove value/profit Q7_RM_Covid_range of recovery strategies Q7_RM_Covid_shut down dramatically affected tightly co-ordinated value chain Q7_RM_Covid-crude value chain negatively affected Q7_RM_Covid-recovery enhanced by shift in mind-sets and boundaries of operating envelope
Refinery optimisation model	Q1_RM_opinion-costs models are remit of Finance Q4_RM_internal and external data critically affects refinery economics Q4_RM_quality and economic ranking propels decision-making Q4_RM_refined, careful calibrations to balance product slate Q5_RM_change to production slate-2 month lead time Q5_RM_critical events may change optimisation Q5_RM_crude slate drives production models for profit/loss Q5_RM_flexibility dependent on product and refinery configurations Q5_RM_modelling based on one plus one plan Q5_RM_one plus one plan creates flexibility to re-plan
Refinery current production cost	Q1_FM_cost strategies based on fixed and variable costs Q1_FM_various relevant and expected elements related IPC (INDIRECT PRODUCT COSTS) Q2_FM_crude is an import cost-cannot determine selling price Q2_FM_inputs cost of raw materials + system costs Q2_FM_premium/demium based on import or buy-in's from other companies Q2_FM_reason for negative margins in refinery Q2_RM_chase profit to improve margins in refinery economics Q2_RM_pursue profit from by-products in configuring product slate Q2_RM_remain close to budget-handle exceptions Q2_RM_specifics on variable costs Q2_RM_trade-off in product slate to make profits Q3_FM_5 O value-raw materials and overhead costs allocated to different products volumes Q3_FM_centrally around volume allocation Q3_FM_IPC not allocated to particular products-no ABC analysis Q4_FM_challenges for cost recovery Q4_FM_detailed explanation of profitability elements-refineries Q4_FM_details of SARM and influence on product costs Q4_FM_details of variable production costs Q4_FM_explanation & implications of product crack Q4_FM_explanation of Brent Oil as benchmark Q4_FM_product crack for by-products create profit margins Q4_FM_product crack for petrol and diesel is not measure of true profitability Q4_FM_refined products benchmarked on international market quotations

	Q4_FM_refined products benchmarked to Mediterranean and Arabian Gulf Q4_RM_adaptations/innovations balanced with safety and regulatory considerations Q4_RM_fixed crude slate drives production models for profit/loss Q4_RM_future markets drives production slate optimisation Q4_RM_refineries prices and profits linked to global markets
Benefits of adopting ABC	Q3_RM_ABC innovation constrained by legislated costs Q6_FM_advantage of demonstrating cross subsidisation of products Q6_FM_advantage of demonstrating profitability of product slate Q6_FM_compensates for environmental-conscious costs & regulations Q6_FM_compensates for restrictive regulatory framework Q6_FM_creates allowances for new specifications in refineries Q6_FM_examples of use of push strategy Q6_FM_insightful and accurate details for unit costs Q6_RM_fully embrace continuous improvement Q6_RM_leadership plan for best optimisation outcomes for refinery Q6_RM_refineries open and available for best fit for their roles Q6_RM_storage capacity affects delivery of profit/value Q8_FM_ABC improve management decision-making Q8_FM_ABC optimisation of strorage vs fast-moving products Q8_FM_ABC possible in Europe owing to potential legislation Q8_FM_ABC supports ownership investment decisions in refinery configurations Q8_FM_ABC supports the de-regulation lobby Q9_FM_ABC would identify profitability for finished products Q9_FM_ABC would improve knowledge on different cost units
Adoption of ABC for accurate costing	Q5_FM_provides accurate working definition of ABC Q6_FM_accurate unit costs are embedded in traditional costing models Q6_FM_elements of accurate costing for by-products Q6_FM_outline of accurate means to set the selling price Q7_FM_necessity for accurate allocation of costs to units Q7_FM_provides views on how ABC could be done Q8_FM_ABC accurate allocation of costs to units for profit purposes Q9_FM_ABC could potentially adjust higher stream costs for better profit Q9_FM_no methodology for IPCs
Challenges of adopting ABC	Q6_FM_ABC challenges-& which profile of units included in ABC? Q6_FM_products are sold on push strategy Q6_RM_create best practice collaborations Q6_RM_plans intensely dependent of excellent data Q6_RM_refineries must not stop/compromise operations Q7_FM_ABC contingent on making assumptions Q7_FM_ABC is highly complex & requires systems development Q7_FM_ABC would be negated by BFP regulations Q7_FM_assumes ABC analysis is being done Q7_FM_critical for management decisions in product slate Q7_FM_inter-dependency of value chain-configuration of units for profit sake is complex Q7_FM_might influence some production decisions
Cost strategy	Q2_RM_cost strategies balanced based on vendor/other value chain cost/profit

	Q2_RM_cost strategies based on fixed and variable costs Q2_RM_cost strategies calibrated on optimising different processing costs Q2_RM_cost strategies fixed in line with global markets Q2_RM_cost strategies for budget consider seasonal implications Q2_RM_cost strategies influenced by product life span
Price regulation in refinery current production cost	Q1_RM_BFP prices determined by Central Energy Fund Q2_FM_BFP set at market quotations for international similar finished product Q2_FM_prices based on BFP-adjusted for import Q2_RM_BFP prices determined by Central Energy Fund Q3_RM_example of cost innovation-ABC/KPFC Q3_RM_model has innovation-ABC/KPFC Q4_FM_BFP is set by government for South Africa Q4_FM_cost of 5 O plus re-allocated overhead costs compared to BFP Q4_FM_costs of BFP plus transport-input costs Q4_FM_SA BFP is equivalent to buying fuel from international markets
Refinery optimisation from technology and human intelligence	Q1_RM_TECH_flow meters related to units of consumption Q1_RM_TECH_linear programming model for refinery Q1_RM_TECH_use of model for optimisation Q2_FM_TECH_use of model for cost of finished product Q3_RM_innovations affected by big systems change Q4_RM_human intelligence applied to optimisation alongside TECH models Q4_RM_innovation driven through HUMAN creative adaptation Q4_RM_TECH_linear programme model creates optimisation scenarios Q4_RM_TECH_linear programming model produces local optimum-negative Q4_RM_TECH_local optimum is not best solution for production optimisation Q4_RM_TECH_modelling based on six months plan & one plus one plan Q4_RM_TECH_production optimisation deeply rooted in multiple variable time-sensitive planning Q4_RM_TECH_use of models-creates quality and economic ranking Q5_RM_innovation driven through HUMAN creative adaptation

APPENDIX F: LANGUAGE EDITING

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08 February 2022

To Whom It May Concern,

RE: Language Editing of Master of Philosophy Dissertation to be Submitted

This letters serves as confirmation that the Master of Philosophy in Accounting Sciences dissertation, titled below, has undergone professional language editing. The following items were reviewed and corrected: spelling, grammar, punctuation, sentence structure, phrasing, table of contents and other lists, as well as formatting of the document, the citations and the reference list (Harvard).

Title: EXPLORING ACTIVITY-BASED COSTING IN SELECTED SOUTH AFRICAN CRUDE OIL REFINERIES

Author: Sanelisiwe Peacefull Makhaza

Copies of the research dissertation with mark-up can be made available upon request. Should you require further information, kindly contact me on AbedaDawood7@gmail.com.

Yours Sincerely,

Abeda Dawood, PhD
Academic Editor
(Professional Editors' Guild Associate Membership No: DAW005)