Exploring the Capacity of Engineers to Perform the Capital Budgeting Function Effectively

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Abstract

The primary goal of manufacturing industries is to maximise profit. This informs their choice of suitable investment projects. However, the capacity and capabilities of the personnel charged with the responsibility of advising the organisation significantly to influence the quality and profitability of the investment project. In many manufacturing industries, engineers play prominent roles in the different units of the industry, including capital budgeting. But does their basic training, as engineers, adequately prepare them for this function? The case study research strategy was adopted, using mixed methods for data collection and analysis, correlating the results with suitable statistical tools. The findings revealed that most of the engineers in the business unit perform capital budgeting using the most elementary tools. To improve their proficiency, engineers require progressive training in business and financial studies. Therefore, the researchers recommend periodic and progressive training programmes for engineers, as well as integrating the engineering staff with other personnel from the business and financial professions in the business unit of the organisation.

Keywords
Capital budgeting, Investment projects, Engineers, Manufacturing industries, Progressive training.

1. Introduction
For many years, capital budgeting has been used as a vehicle for decision-making when choosing suitable investment projects for large engineering and manufacturing firms. Saxena (2015) describes capital budgeting as the process of making investment decisions, using suitable tools for objective analysis to guide the deployment of resources for long-term use, and creating benefits for shareholders. The many capital budgeting tools and techniques available for the evaluation of investment processes include discounted cash flow (DCF) analysis, accounting rate of return (ARR) analysis, profitability index (PI) analysis, and many more. Adopting suitable capital budgeting tools can be extremely useful in the decision-making process for the selection of projects when the aim is to maximise shareholder wealth. However, one of the major challenges that exists in the field is that engineers who function as project sponsors or implementors are not always sufficiently knowledgeable of the essential workings of economics and its impact on engineering projects (Yihui et al. 2021). Firms should seek professionals who are knowledgeable of the practices of capital budgeting to enable the organisation to make sound investment decisions (Michelona et al. 2020).

Inadvertently, many investment projects are chosen or endorsed based on non-economic reasoning. Some of the commonly adopted approaches to project selection include the following.

- • Overconfidence bias, where individuals tend to overestimate their ability to do certain things (Ramos 2018). In these cases, engineers become so familiar with something, they tend to think that their entire knowledge of the system is superior. At this stage, they may easily ignore vital capital budgeting data that are critical to the decision-making process and make decisions based on subjective assessments (Ramos 2018).
- • Keeping up with project, company, or industry trends (copycat strategies). This does not always mean that this is the best way to maximise profits (Downey 2018).

This research explored the use and understanding of capital budgeting practices amongst engineers working in a South African petrochemical industry. The study was conducted in the business unit of a South African petrochemical company. For ethical reasons, the name of the petrochemical company will not be mentioned in the narratives in this research report but the information provided is real. To execute this study, existing literature was explored to determine the use and benefits of capital budgeting tools in a typical manufacturing firm. Following this, an empirical study was conducted to determine the understanding and use of capital budgeting tools in the business unit of a South African petrochemical firm.

Over the years, several studies have been done on capital budgeting practices in firms worldwide. From a South African perspective, the examination of the engineering and financial literature showed limited studies published on capital budgeting, but none on the use and understanding of capital budgeting amongst engineers in the South African petrochemical industry. Therefore, this study is contributing to closing this gap by exploring the understanding and use of capital budgeting tools amongst engineers in the South African petrochemical industry. The targeted population for this study was employees of the technical support function in a South African petrochemical organisation.

The rest of this paper is organised as follows: Section 2 provides a review of existing literature and information on the use of capital budgeting tools and the investment selection process. Section 3 explains the research approach adopted as well as the methods employed in data collection and analysis. Section 4 presents and discusses the gathered data and Section 5 draws conclusions from the research findings and presents recommendations. The last section provides a list of sources cited in this paper.

1.1 Objectives
Over the years, several studies have been done on capital budgeting practices in firms worldwide. From a South African perspective, the examination of the engineering and financial literature showed no studies published on the capital budgeting use and understanding amongst engineers in the South African petrochemical industry, or any other industry. While some studies have been performed regarding capital budgeting use in South African private sector companies, none have focused on engineers. Therefore, the objective of this study was to explore the understanding and use of capital budgeting tools amongst engineers in the South African petrochemical industry to address this gap in the literature.

2. Literature Review
The literature reviewed in this section encompasses the investment selection process, the capital budgeting process, and tools. The section culminates in the identification of gaps in literature and the attempt of this research to address the observed gap.

2.1 Investment Selection Process
The process of selecting suitable investment projects is not linear but involves a combination of interrelated processes. The process contains a variety of methodologies that streamline the comparison of alternatives on an economic basis (Yonesawa and Richards 2016). Given an investment opportunity, a firm needs to decide whether a certain investment will generate net economic profits or losses for the company. In the research efforts of Beaves (1993), a four-stage model was proposed, namely the identification of investment opportunities, preparation of a bid/proposal, selection and implementation of a project, and control, evaluation, and post-audits.

Investment project selection entails the well-considered filtering of projects to assess a project's alignment with the company's strategy. It requires a comprehensive feasibility study and the development of a suitable business implementation model. Projects may be driven by either the need (e.g., new conveyor belts because the current ones are obsolete) or the opportunity (e.g., purchasing a bankrupt neighbour's premises) for investment. Whatever the motivations, the selection process should be guided by a detailed bid proposal. The bid-proposal stage is where projects

are defined and evaluated according to their business objectives, namely financial and non-financial objectives. Financial objectives are met when a project sustains operations, reduces costs, increases sales and, therefore, improves the earnings of the company. Financial objectives may be assessed using several techniques. Non-financial objectives are met when the benefit of a project does not necessarily result in increased earnings. The motive for such projects may be environmental compliance, safety, personnel wellness, and compliance with government requirements and laws. Before the investment choice is made, the proposal documents should include implementation processes.

The investment implementation document is critically evaluated by a wider representation of relevant stakeholders. This phase of the investment selection process requires objective inputs from senior management, experts (in-house and external), a comparative study report on a similar project, and the critical evaluation of the merits and risks of projects. Detailed project implementation reports facilitate the acceptance of the proposed investment project. Often, implementation proposal documents present multiple alternative investment opportunities, evaluated and weighed against the organisation's strategic objectives, to guide senior management in their decision-making. Although the final decision has not been taken on the proposed investment project, it is important to establish the process of monitoring and evaluation (M&E) or post-implementation audits (Okwir et al. 2018). As a guide for the final decision to accept the investment project, a prototype of the project implementation proposal is developed and assessed. The information from the M&E is compared to the forecast from other project proposal documents. The outcome of the M&E provides a birds-eye view of what the real-life project may entail, the learning and insights required, the actual return and performance of the proposed project measured against the projected performance, the possible deviations, reasons, and remedial solutions for deviations. The M&E document is complemented with a SWOT (Strength, Weakness, Opportunity, Threat) analysis, to guide the final decision (Frank 2013).

2.2 Capital Budgeting Process and Tools

Capital budgeting is a planning instrument used by organisations to evaluate and decide on how to apportion resources among investment ventures (Al-Mutairi et al. 2018). Moten and Thron (2013) indicated that twelve capital budgeting methods are available including the following: net present values (NPV), internal rate of return (IRR), annuity, earnings multiple (P/E), adjusted present value (APV), payback period (PB), discounted payback, profit index (PI) and sensitivity analysis. However, not all are usable in all situations in capital budgeting practices. For example, IRR should be relied upon if investments are mutually exclusive or have multiple rates of return. Some of these techniques are described below.

The **NPV** is the difference between the present value of cash inflows and the present value of cash outflows over a period. Projects with a positive NPV are those that will create value for the shareholders and can be accepted based on economic benefit. The higher the NPV, the better. However, some projects with a negative NPV may sometimes be considered. Examples include investments in research and technology which may give the company good returns in the future. The benefits of using the NPV are as follows (Beaves 1993):

- The NPV takes into consideration all the inflows, outflows and risks involved. Therefore, the NPV is a comprehensive tool taking into consideration all aspects of the investment.
- The NPV method not only states if a project will be profitable or not but also provides the value of total profits.
- The NPV's reinvestment occurs at the cost of capital, which is a conservative assumption.

The **IRR** is a calculation used to estimate the profitability of potential investments.

The IRR is calculated by the condition that the discount rate is set such that the NPV equals zero for a project. The benefit of using the IRR is that it allows investments to be analysed for profitability by calculating the expected growth rate of an investment's returns and expressing this as a percentage (Al-Mutairi et al. 2018). However, the IRR has one drawback, it does not account for the project size when comparing projects (Moten and Thron 2013). Cash flows are simply compared to the capital outlay generating the cash flows. This can be troublesome when two projects require significantly different capital outlays, but the smaller project returns a higher IRR. Another shortcoming is that the IRR is derived from the assumption that all future reinvestments will take place at the same rate as the initial rate (Moten and Thron 2013). This assumption is problematic because there is no guarantee that equally profitable opportunities will be available as soon as cash flow starts. The risk of receiving cash flows and not having good enough opportunities for reinvestment is called reinvestment risk.

Whenever an NPV and IRR conflict arises, it is advised to always accept the project with a higher NPV. This is because the NPV does not suffer from such a problematic assumption. After all, it assumes that reinvestment occurs at the cost of capital, which is conservative and realistic (Arshad 2012).

2.3 Summary
Various capital budgeting tools were discussed in this section. These have unique aims, uses, advantages, and disadvantages. The most appropriate tools must be used depending on the project objectives and the nature of cash flow, amongst other factors. In some cases, projects with a negative net cash flow may also be considered. Some tools are more complex than others and require in-depth finance knowledge, while others are more straightforward. Although significant literature is available on capital budgeting methods of firms around the world, there is limited literature available on the South African petrochemical industry.

3. Methods
The case study research strategy was considered most appropriate for this study (Yin 2014). The case study approach to research provides an opportunity for a detailed study of the research subject through observation, and evaluating information about the different aspects of the same subject (Zainal 2007). The population used for this research was purposively selected from engineers in the business unit of the firm. Purposive sampling is a type of non-probability sampling where the researchers rely on specified pre-qualification criteria for selecting participants (Alkassim and Tran 2016). To qualify for participation in this exercise the respondents had to have a minimum of an undergraduate educational qualification in any engineering field and must have served at least one year in the employment of the company and work in the business unit of the organisation. Consequently, as shown in Table 1, 74 of the 86 engineers serving in this unit qualified to participate in the research.

Table 1. Characteristics of the target sample population

Element	Grouping	Frequency	Percentage
		86	
Gender	Female	27	31
	Male	59	69
Duration of Employment	<1 year	11	12
	1-3 years	36	43
	4-8 years	22	26
	<8 years	16	19

Source: Researcher's own construct

4. Data Collection
The Survey Monkey tool was used for data collection and analysis. The tool can collect and analyse both qualitative and quantitative data and present it in a suitable format for further analysis, such as individual responses, a summary of all responses, charts and graphs of the data, and filtering and comparing the data. The results were correlated with statistical tools for regressions. The details of the process, results, analysis, findings and discussion follow in the next section.

5. Results and Discussion
5.1 Numerical Results
As this paper is an excerpt from a larger research effort, the research findings discussed in this section are limited to the demographic profile of participants, capital budgeting process, capital budgeting tools and proficiency in capital budgeting.

5.2 Demography of Participants
The first part of the survey questionnaire was dedicated to exploring the personal information of the participants in terms of educational qualifications and years of experience in the employ of the industry. Although the request to participate in the exercise was sent to 74 staff members of the business unit, only 34 respondents agreed to participate, representing a 45.95% response. All the participants satisfied the pre-qualification conditions in terms of educational qualification and years of service, as shown in Table 2. They possess a minimum of an undergraduate degree in engineering and have spent more than one year in the employ of the industry. Further analysis of the table shows that 25 (74%) have an undergraduate degree in engineering, while 9 (26%) have higher degrees.

The demography of the respondents shows that they are suitably qualified to participate in this research and the information provided can be trusted as valid responses to the research questions. The research did not evaluate the years of experience, the time and the specific business or finance qualification acquired by the 19 participants. Having worked in the business unit of the organisation for many years, all the participants have learned the art of capital budgeting from experience on-the-job, since learning from experience plays an essential role in understanding holistic work processes (Collin 2004).

Table 2. Demography of the respondents

Element	Grouping	Frequency	Percentage
Number of Valid Responses		34	100
Education	Undergraduate	25	74
	Postgraduate	9	26
Duration of Employment	<1 year	-	-
	1-3 years	6	18
	4-8 years	14	41
	<8 years	14	41

Source: Researcher's own construct

5.3 Capital Budgeting Process

Many of the respondents (21 or 62%) indicated that the 'identification of investment opportunities' is the most important step in the investment process, as shown in Table 3. Others suggested implementation of project (18%), selection of project (12%), and impact evaluation and post-audits (9%) respectively, as their preferred starting points in the search for investment.

Table 3: Most important capital budgeting process phase

Capital budgeting process	Respondents	% Respondents
Identification of investment opportunities	21	62
Preparation of a bid/proposal	0	0
Selection of project	4	12
Implementation of project	6	18
Impact evaluation and post-audits	3	9

Source: Researcher's own construct

The importance attached to the investment opportunity identification could be attributed to the fact that the sample population, engineers, work very closely with the assets that are under review and are therefore well positioned to identify and understand investment opportunities. This is unlike finance (accountants) or legal professionals who would have preferred other attributes because they are usually involved with general management and do not work directly with assets (Matthews 1999). Although most of the participants indicated that the identification of investment opportunities was the most important factor in the capital budgeting process, the importance of other factors should not be taken for granted (Beaves 1993).

5.4 Capital Budgeting Tools Usage

Effective decision-making when choosing an investment is predicated on the quality of information supported by relevant data complemented by financial analysis. In this research, the top three tools used by engineers for financial analysis to support the investment choice are the IRR (74%), NPV (68%) and payback period (56%). The tool used the least is the ARR (12%), as shown in Table 4. It is interesting to note that some of the 34 participants may have identified their preference for more than one tool. As is common in research, there is room for outliers. That is why it is not surprising that one participant indicated that he or she does not use any tool. It may be that the respondent marked this option in error, was tired, or was not sure of the correct answer.

The high use of the IRR, NPV and payback period tools can be attributed to the fact that these tools are relatively easy to understand and calculate. According to Hofstrand (2013), the first two methods, along with the third (payback

period) method, are the least complex methods of all. However, the preference for the use of the IRR over the NPV tool is not supported by financial theory that advocates the use of the NPV over the IRR tool because of its ability to correctly assess projects with different lifespans (the IRR method can sometimes give incorrect results in this regard) (Arshad 2012). According to Krause (2002), using relatively simple methods results in less successful capital investments. The ARR tool is the least used in the organisation investigated. This is not surprising, since this tool is an in-depth method that requires a fair amount of financial education, background knowledge and proficiency. It could also mean that the respondent who indicated that he or she does not use any tool (3%), may be depending on subjective, pet project or other biased approaches based on years of experience and leadership positions in the industry (Winterbottom et al. 2008).

Table 4: Capital budgeting tools used

	Number of Respondents	% of Respondents
Internal rate of return (IRR)	25	74
Net present value (NPV)	23	68
Payback period	19	56
Discounted cash flow (DCF)	14	41
Profitability index (PI)	5	15
Accounting rate of return (ARR)	4	12
None (I don't use any tools)	1	3

Source: Researcher's own construct

Research shows that the practitioners who use the ARR, PI and DCF tools are individuals with in-depth knowledge, through business and finance qualifications, and cognate practice (Krause 2002). This includes engineers who have developed themselves in business studies, such as earning master's degrees in business administration. Although many techniques are available for the development of capital budgeting Michelona et al. (2020), observe that many of them, especially the complex techniques, are not being used by most engineers. The reason is that many engineers do not have formal education and training in business and financial disciplines.

5.5. Capital Budgeting Proficiency

Although many of the respondents (65%), affirmed that they are proficient in the use of capital budgeting tools, a correlation test was conducted to measure the relationship between engineering qualifications and years of working experience along with the possession of appropriate business or financial qualifications on proficiency in the practice of capital budgeting. The multiple regression model adopted contained three independent factors, namely highest level of education, possession of a business degree and number of years of experience. These three factors were measured to determine which of them adequately correlated with proficiency. A Pearson correlation test was performed, and the results are presented in Table 5.

Table 5: Correlation coefficients between proficiency and measured variables

		Education Level	Business Qualification	Years Experience
Proficiency	Pearson Correlation	-0.57	0.469**	-0.175
	Sig. (2-tailed)	0.745	0.004	0.323
	N	35	35	34
**Correlation is significant at the 0.01 level (2-tailed)				

Source: Researcher's own construct

The Pearson correlation prescribes factors between 0.3–0.5 as having a moderate positive correlation (Pallant 2010). Thus, in Table 5, the results show that only the possession of a business qualification has a positive correlation with the proficiency test (0.469). Furthermore, education level and years of experience, both having coefficients close to zero, suggest that they have a low correlation with proficiency.

Similarly, within the same margin of 0.3–0.5, the standardised Beta coefficient is considered statistically significant to the proficiency test (Erbaugh et al. 2017). The correlation test revealed that the possession of a business qualification makes the largest contribution to the dependent variable with a coefficient value of 0.457. Educational level and years of working experience both have coefficients close to zero and are therefore not statistically significant, as shown in Table 6.

Table 6: Regression model result summary

	Mean	Standard Deviation	Pearson Correlation	Standardised Beta Coefficient	Sig.
Proficiency	1.34	0.482			
Education Level	2.29	0.458	-0.57	0.036	0.831
Business Qualification	1.43	0.502	0.469	0.457	0.01
Years Experience	3.18	0.758	-.175	-0.091	0.587

Source: Researcher's own construct

In a nutshell, the possession of an engineering qualification, without suitable business or financial qualifications and years of experience, has a weak correlation with proficiency in the practice of capital budgeting, as shown in both the Pearson correlation and the standardised Beta coefficient test. Therefore, to improve the proficiency of the engineers who participated in this study, the organisation should explore the prospect of progressive training of their engineering staff in business and financial studies. Human capacity development through training invigorates and incentivizes employees and not only leads to improved quality of work but also improved employee retention (Wright 2000).

6. Conclusion
Capital budgeting as an important tool for effective investment decision-making, is given considerable attention by manufacturing industries. The capital budgeting process is executed by the in-house personnel of an organisation or through an outsourced service of specialist consultants. If in-house personnel are to be used, it is imperative to ensure that the personnel have the capacity and capability to perform the functions adequately. Over the years, several studies have been done on capital budgeting practices in different industries worldwide. However, there was little focus on engineers performing the task of capital budgeting in manufacturing industries, especially in South Africa. Therefore, this research explored the understanding and use of capital budgeting practices by engineers working in a South African petrochemical industry.

To achieve the aim and objectives of this research, appropriate questions were developed and included in the survey questions to elicit responses from participants. The demographic information indicated that the respondents were aptly qualified and had provided useful responses to the survey questions. The analysis of results and discussion of the research findings provided sufficient information on how the aim and objectives of the research were achieved.

In conclusion, the research established that engineers in this South African petrochemical industry have a good understanding and use of some of the basic tools for capital budgeting but do not possess the required proficiency for the use of the technically complex tools most suitable for investment decisions. However, they seem comfortable with the use of the NPV, IRR and payback period methods and have the potential to improve their proficiency in the use of multiple or complex tools through short- to medium-term training sessions. This was true for personnel with business and finance qualifications who work alongside these engineers in the same unit or recirculate the engineers around other units in the industry.

As this research was conducted in one unit of a petrochemical industry in South Africa, the research findings cannot be adopted for general use without appropriate contextualisation. Therefore, this research recommends that this exercise should be expanded to cover more units in the same industry and include other petrochemical industries in South Africa to elicit more information for wider use in the Southern African sub-region. To improve their proficiency, engineers require progressive training in business and financial studies. The researchers consequently recommend periodic and progressive training programmes for the engineers, as well as providing the staff with other training from

the business and financial professions' in the business unit of the organisation. Similarly, it is recommended that the teaching of capital budgeting techniques should be included in the academic training curriculum of engineering institutions.

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