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# Factors affecting sustainable growth for South African high voltage electrical construction companies

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# Factors Affecting Sustainable Profitable Growth for South African High Voltage Electrical Construction Companies

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**A research article submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Business Administration**

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# DECLARATION

I, **Simphiwe Zondi**, declare that this research article is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the Graduate School of Business Administration, University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.



**Simphiwe Zondi**

Signed at **Midrand o**n the **7th** day of **February 2018**

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- To God almighty who has made this possible. At times when I felt like giving up he was always with me and assured me that he will not give me something which is beyond my reach.
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# ABSTRACT

Keywords: FCM, profit, growth, sustainable, construction, high voltage.

The construction industry remains a critical contributor to the South African economy. However, the construction industry performance has been on the decline since 2010. Between 2014 and 2015, revenue declined by 6% while profits declined by 54% for the same period. The 2015 secured order book for the industry also decreased by 4% when compared to the 2014 order book. This decline in performance has put employment in the sector under pressure, as 76,000 jobs were lost between 2014 and 2015. The challenges that have faced the industry in terms of achieving suitable profitable growth within the high voltage segment is investigated in this work. From the Fuzzy Cognitive Mapping (FCM) simulation, it is observed that factors which have a marginal impact on profit and growth are skills development, workload, remuneration, education and experience. The close management of these factors remains critical for achieving sustainable profitable growth in this industry.

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## INTRODUCTION

Despite the importance of achieving sustainable profitable growth, evidence reveals that very few companies manage to show either, let alone both. In fact, there is often tension between revenue growth and increased profitability, as well as between short-term gains and sustainable long-term performance (Chakravarthy & Lorange, 2008). This becomes even more of a concern in a contracting economy such as South Africa, and an industry which is heavily affected by different factors at macro and micro level.

The construction industry is a significant contributor to employment and growth in South Africa, however the industry has been slumped since the 2010 Soccer World Cup projects (PWC, 2015). The construction industry employs some 1,362 million employees, a decline compared to 1,438 million in 2015 (Statistics South Africa, 2016). According to PricewaterhouseCoopers (PWC) SA construction industry trends, in 2015 the revenues for the construction industry declined by 6%, from R164.2 billion in 2014 to R144.6 billion in 2015, with net profits dropping by 54% from R2.4 billion to R1.1 billion respectively (PWC, 2015). For the first time in five years, the secure order book has also decreased by 4% when compared to the 2014 order book (PWC, 2015). These findings are based on the financial results of the leading heavy construction companies listed on the Johannesburg Stock Exchange (JSE).

This decline is due to many factors at a macro and micro level and these different factors, including their influence on the sustainable profitable growth of high voltage construction companies within South Africa were analysed in this work. At a macro level, the economy is contracting and inflation is increasing, while there is also much uncertainty looming around the potential downgrade to junk status. At a micro level, this industry has seen numerous new entrants in the form of small companies including some with strong political connections. In addition, Original Equipment Manufacturers (OEMs) competing in this industry are gaining more bargaining power due to the Department of Trade and Industry's (DTI) policy on designated products (Chibanguza, 2016).

The high voltage construction business is focused on providing turnkey solutions for its clients. This business is segmented into substations, overhead power lines and renewable energy projects, but excludes power station

construction. This business is further segmented into transmission, which are construction projects above 132kV voltage levels, and distribution, which comprises the voltage levels below 132kV. These companies are sometimes referred to as Engineering, Procurement and Construction (EPC) companies, hence the term turnkey solutions. This essentially means that once the contract is awarded, designs are completed and all the key equipment and material is then procured and delivered to site, following which construction can commence up to the commissioning and handing over of the project to the client. The clients who support this industry are both public and private entities including, but not limited to government entities, municipalities, Eskom, Transnet, mines, developers and Independent Power Producers (IPPs). The majority of the contracts are awarded through the tender process, with the balance being through negotiated contracts. The tender process can be issued either through a closed approach, which generally means that the public is invited to bid and the tender prices are not announced to the public, or an open approach in which opening prices are publicly announced at the tender submission (Supplier Select, 2014). Different criteria are used through the tender adjudication process in order to establish the successful bidder and this remains the full discretion of the client. Negotiated work, on the other hand is mainly prevalent in the private sector, where eligible companies are invited to bid for a contract and prices are usually not announced, with selection being based mainly on capacity to execute, social capital and on past performance.

Some high voltage construction companies are OEMs, meaning that they control the upstream value chain. In other words, they can apply vertical integration strategies to be competitive. On the other hand, the electrical construction company's competitiveness generally lies in their product agnostic approach, where they can offer a combination of solutions compared to OEMs which are limited to their own solution for electrical construction contracts.

This work was based on South African high voltage construction companies that were registered with the Construction Industry Development Board (CIDB) under the category of Grade 8 and 9EP (Electrical Engineering Work – Infrastructure) at the time of study. In an analysis that was conducted by one of the largest high voltage construction company in Africa, Consolidated Power Projects (Pty) Ltd, it was established that there has been a decline in the number of tenders in the market, with increased systematic inefficiencies on executing contracts which have been secured.

The Fuzzy Cognitive Mapping (FCM) methodology was used to establish the factors that affect the sustainable profitable growth for high voltage construction companies. The research dug deeper into the relationships of the

different factors and their impact, with a view to establish a strategic position for these companies to achieve sustainable profitable growth.

## LITERATURE REVIEW

The aim of this work was to identify business factors affecting sustainable profitable growth for high voltage construction companies in South Africa. For this reason, the literature that was reviewed was based around the factors that have been identified and the findings of previous researchers in the construction field. The PWC SA, 2015 construction industry trends identified 10 risks or factors affecting South Africa's construction industry as follows:

- Broad-Based Black Economic Empowerment (B-BBEE) and transformation and the uncertainty regarding the legislation of the construction BBBEE sector codes, which may necessitate the restructuring of many construction companies.
- Industrial action – as much as industrial action is a sign of a maturing democracy, strikes in South Africa have reached a level where they are harming the productivity of projects and are also becoming more and more violent, in the process inflicting significant damage to the performance of the construction sector.
- Talent management and staff retention – the construction industry is labour intensive and requires highly-skilled human resources for execution. Managing and retaining top talent is proving to be more of a challenge for construction companies due to the shortage of skills in South Africa and the ever-rising demand for these resources.
- Growth and expansion – competition in the construction industry has intensified due to new entrants, which affects growth negatively and is further compounded by the government's reduced spend on infrastructure. There is also a low business confidence due to the political climate and labour unrest in South Africa, the result of which is reduced foreign investment in the country.
- Project execution – the shortage of skills in the construction sector has led to a compromise in the delivery of quality projects, which leads to many inefficiencies and reworks during project execution.
- Liquidity risk – cash constraints remain a huge risk for the construction industry. The challenge is that there are no upfront payments and that a significant amount is held up in retention, along with delayed payments during construction and delays in the execution of projects.
- Health, safety and environmental sustainability – the construction industry remains highly dangerous and records the highest number of injuries and fatalities when compared to other industries. This has necessitated the tightening of health, safety and

environmental compliance, which affects the tender pricing of construction companies.

- Legislative and regulatory compliance – the regulatory landscape is increasingly complex in this industry. The designation of electrical equipment and steel structures has led to reduction in profit margins within the construction sector.
- Tender risk – the tendering process is becoming increasingly complex and requires commercially-educated personnel, while competition is also on the rise. This poses the risk of companies winning tenders but not at the right price.
- Credit management – most clients especially in the private sector are showing signs of financial destress, which poses a risk for the construction company's debtor's recovery.

The literature review sought to understand these factors in-depth and take into consideration other factors that might affect the South African construction industry apart from those listed above. This was achieved by reviewing work that has been done on the survival and growth of construction companies within South Africa, South African construction industry trends, key strategic factors for construction companies, and approaches to bidding strategies in the South African construction industry.

**Sustainable profitable growth defined**

According to Chakravarthy and Lorange (2008), sustainable profitable growth refers to the company's growth in revenue, sales and free cash flow over a determined period. Sustained profitability in the same light refers to the Return of Capital Employed (ROCE) and Return of Equity (ROE), which are maintained at levels above the cost of capital (Chakravarthy & Lorange, 2008). In their research, Chakravarthy and Lorange (2008) define a sustainable company as one that maintains its profitable growth over a ten-year period. In her sustainable growth model, Radasanu (2015) defines sustainable growth rate as the maximum percentage of sales, assets or profit growth when the financial and operational parameters agree with management objectives and with the company's expectation of the market. In this work, sustainable profitable growth is defined as economic profit and growth in sales, revenue and shareholder value that is maintained at levels in line with the required shareholder's expectations over a predetermined period.

**Background of the electricity infrastructure industry**

To understand the high voltage construction business, it is essential to have some background on the electricity power system. Electricity is generated at low voltage levels in order to minimise the floor area of generators and the size of the electrical apparatus (Short, 2004). Once generated, electricity is stepped up to high voltage levels for transmission over long distances to distribution substations, where it is then stepped back down to medium and lower

voltage levels for industrial and domestic use (Short, 2004). This process of stepping up electricity to high and extra high voltage levels is done to reduce losses and current carrying conductor size when transmission is over a long distance (Short, 2004). The stepping up or down of electricity is achieved by the introduction of substations, and the transmission and distribution is achieved by the connection of transmission lines (Short, 2004). The system is interconnected to ensure that there is continuous supply of electricity and interruptions are minimised. The interconnection is achieved by the introduction of switching stations at transmission and distribution levels, which allows the supply of electricity to be reliable and flexible.

The power grid or electricity system in South Africa is owned and operated by Eskom, who then sell electricity to municipalities, industry and households for consumption or resale by municipalities (Eberhard, 2004). The transformation, transmission and distribution of electricity opens demand for special skills to participate in the construction of substations and overhead powerlines directly with Eskom, municipalities or industry. This demand therefore necessitates the existence of electrical construction companies, which are then segmented into high, medium and low voltage levels. This work only focuses on construction companies which are active in the high voltage space. The typical scope of a high voltage construction project would include but is not limited to clearing of a green field, establishing a platform by performing major earthworks, construction of the civil and building infrastructure, erection of mechanical steel structures and electrical equipment, and commissioning and integration to the existing power system.

**South African construction industry trends**

The construction industry plays a significant role in the reduction of the unemployment rate in most economies, especially the South African economy. The South African construction industry continues to slow down as government spend on infrastructure projects is reduced. At the same time, there seems to be an influx of new construction companies in the industry. In a study conducted by the Construction Industry Development Board (CIDB), Supply and Demand Quarter 1 (2016), the following factors attributed to the sustained pressure on the construction industry growth (CIDB, 2016):

- Weak economic growth outlook, currency volatility, rising debt, high interest rate due to downgrading and fiscal consolidation;
- Limited scope for private sector investment due to low confidence;
- No growth in public sector infrastructure expenditure of the Medium-Term Expenditure Framework (MTEF), and possibly negative growth;

- Public infrastructure expenditure projected to fall by 5.4% in nominal terms in 2016/17; and
- Deterioration in key indicators such as awarded contracts and company current order books. The South African construction industry trend and outlook is on a downward trajectory, which has a huge impact on the performance of the economy and the country's employment rate. The survival and growth of construction companies rely on examining and understanding the factors that are affecting their profitable growth with a view to strategically position themselves to counter the negative effects.

**Factors affecting the performance of construction projects**

The most important factor that affects project performance is winning the right project at the right price, as failing to do so could lead to growth in revenues with erosion in margins (Upneck, 1984). The challenge then becomes identifying and winning the right project and not going after all projects in the tendering market. This section reviews some of the performance factors within the construction industry and the impacts they have on different stakeholders. These factors include: cost, time, quality, productivity, client satisfaction, health, environment and safety, and skills development.

**Impact of talent management and staff retention in construction**

South Africa is faced with the challenging phenomenon of a brain drain. As much as this is a problem at a macro level, it is even more of a problem at industry level. This is made worse by the skills shortage that the country faces in different industries. The construction industry is no exception, and trends indicate that there is a great deal of brain drain activities at sectoral level due to the scarcity of talent in the country. A study by Muteswa and Ortlepp (2011), "Contributing factors to potential turnover in a sample of South African management-level employees" found that the main contributors to turnover were the leadership or management style, career path strategies and rewards on offer (Muteswa & Ortlepp, 2011). This is true in the construction sector as well, as with most sectors; however, family time and stress also play a significant role in construction industry staff turnover. The construction industry tends to be demanding in its nature and employees find themselves more at work than spending quality time at home. Today's marketplace is very competitive and construction companies are now seeing the value of attracting and retaining the best and brightest employees with a view to achieve more market share and improve their profitability. The sustainability of construction companies lies in their expertise, and it is therefore important for firms to ensure that their employees are engaged all the time to ensure that they retain the necessary critical skills (Ntuli & Allopi, 2014). There are seven problems that

arise from staff turnover, namely: increased workload, training and development costs, low staff morale, lower productivity, management frustration, compromised customer service and poor performance (Thomas, 2015). The construction industry also faces the challenge of an aging workforce. To curb this phenomenon, skill and knowledge transfer strategies become crucial, which is a challenge as most construction companies are less inclined to integrate flexible work arrangements in their organisational designs when compared to other sectors (Sweet & Pitt-Catsouphes, 2010).

**Effective construction project execution**

Aligned with skills development, effective project management plays a significant role in maximising project profits through driving efficiencies in the execution process. Effective project execution ensures that resources are utilised efficiently and in accordance with the project plan. This therefore plays a huge role in the growth and profitability of construction companies.

The effectiveness of project execution in the construction industry relies greatly on good project management from inception to delivery. Project delays is one of the contributors to projects inefficiencies. In their research, Sunjka and Jacob (2013) identified 38 causes of project delays. These are categorised as client-related issues, labour- and equipment-related issues, material-related issues, consultant-related issues, community-related issues, contractual relationships and external issues (Sunjka & Jacob, 2013). Gwaya, Masu and Oyawa (2014) presented a model for measuring the success of construction projects. The Project Success Index (PSI) uses seven criteria to measure efficient and effective project execution, and these are as follows: project time, cost, quality, human resources, scope management, project performance and client performance (Gwaya, Masu & Oyawa, 2014).

Project execution covers most of the factors that affect profitable growth for construction companies, because if done efficiently and effectively profit and growth is inevitable.

**Impact of cash flow management in construction**

As the saying goes, cash is king, and this remains true for most industries and especially the construction industry. The majority of the contracts in the construction industry are structured in such a way that contractors will have to outlay capital for construction resources and material before they get paid. There are however a few contracts where the client is willing to pay a deposit or an advance payment. This is further compounded by the fact that most contracts withhold 5 – 10 % of the contract value in retention and an additional 10% in bond securities.

This challenge on cash flow leads to profits being eroded and growth being stunted. Financial planning and seamless execution

therefore play a significant part in the survival of construction companies across the globe (Odeyinka, Kaka & Morledge, 2003). When compared to other industries, the level of insolvencies in the construction industry is high, which is attributed to lack of financial control and poor management (Mutti & Hughes, 2002). Other factors that contribute to variations between forecasted cash flow and actual cash flow are: client changes to designs, inclement weather, labour shortages, slippages in production targets and delays in settling of claims (Morledge, 2002).

Poor cash flow management ultimately leads to reduced Internal Rate of Returns (IRR) and leaves the business with little or no cash to fund its future growth.

**Safety, health, environment and quality requirements in construction projects**

The construction industry has earned a reputation of being a dangerous and highly hazardous industry over the years. According to research, construction workers are two to three times more likely to die on the job when compared to other industries (Muiruri & Mulinge, 2014). Nevertheless, construction managers often believe that when implementing health and safety requirements, costs are usually increased and profits are in turn reduced, when in fact the implementation of health and safety requirements in construction projects results in increased productivity which therefore increases profitability (Muiruri & Mulinge, 2014). Traditional project management parameters are constituted of time, cost and quality; however, a significant percentage of construction projects have failed to meet these parameters because health, safety and the environment were excluded in project priorities (Smallwood, 2010). Health, safety and the environment contribute largely to the efficient execution of a project; hence the management of the quality thereof is important for the competitive advantage of construction companies (Bhutto, Griffith & Stephenson, 2004). For construction companies to achieve sustainable profitable growth, it is therefore important for them to focus on managing these parameters, as failure to do so may lead to non-conformance. Through research conducted by the Associated General Contractors in the United State of America, it was established that the cost of rework or cost of non-compliance averaged 12.4% of the contract value while only 87.6% was the cost of doing the actual work. The 12.4% might be even higher in countries like South Africa, and reducing the percentage of non-conformance will ultimately result in improved profits.

**Legislative and regulatory compliance in the construction sector**

Legislation and regulatory compliance play a significant role in the South African construction sector. This has the potential to influence profitable growth both positively and negatively. The introduction of BBBEE in South Africa has led to new construction companies entering the

market, thus putting margins under pressure for companies who have been operating in this industry for decades. The requirements for complying with BBBEE have led to most companies restructuring, though a lot of uncertainty looms around the future of this industry (PWC, 2015). This uncertainty is made even worse by the delays in finalising the amended BBBEE codes for the construction sector (PWC, 2015). Unfortunately, compliance with regulation is a must and this influences the sustainability of these companies, let alone growth and profitability. In the quest to assist local manufacturers, the DTI has designated some of the equipment and material used in the construction industry, which has led to certain manufacturers having a monopoly or oligopoly in their industries. The result of this is an increase in input cost for construction companies, who in turn must reduce their profit margins to be competitive. Although this might be good for the manufacturers, the effect on the growth of construction companies is significant. Compliance to health and safety is important, however the introduction of the new Construction Regulations 2015 in South Africa has proven to be a challenge for many construction companies (Smallwood, Haupt & Shakantu, 2016). This poses a challenge during the tendering process and in turn the profitability of these companies. The main challenge is that most small to medium enterprises do not adhere to these regulations, and their bidding price is ultimately therefore more competitive than a company which has factored in all the requirements of the regulations. The impact of this is that new entrants in the industry are taking most of the market share and thus profitable growth is compromised.

**Corruption in the construction industry**

The tendering system is an efficient and mostly fair approach to appointing construction companies. However, over the years this system has been compromised by the increase of corruption in this industry. Corruption has many implications for construction companies, but the most relevant implication is the sustainability and growth of these companies.

Hartley (2009) pointed out that although the paying off government officials by construction companies to receive special consideration in the award of tenders exists, the most common practice is collusive tendering, lack of honesty and fairness amongst stakeholders, bad industrial and workplace practices and poor or non-existent occupational health and safety compliance (Hartley, 2009). This sort of practice has huge implications for the construction company's profitability, growth and reputation or sustainability. Zou (2006) argues that corruption is a phenomenon which is deep-rooted in mankind and is hence not easy to eliminate, but there is nevertheless an urgent need to develop strategies in order to minimise it (Zou, 2006). Bowen, Edwards and Cattell (2012) concluded that the most common forms

of corruption encountered in the South African construction industry are conflict of interest, tender rigging, collusion, fronting and kickbacks. These are prevalent in both the public and private sector, with government officials – which in most cases are also the clients, contractors and subcontractors – playing a significant role in corruption activities (Bowen, Edward & Cattell, 2012). It is without doubt that corruption is a significant factor in the sustainable profitable growth of construction companies in South Africa. Research done in Nigeria on the causes and solutions of corruption in the construction industry discovered this to be profit maximisation by the contractor (Olusegun, Benson & Esther, 2011).

**Challenges facing construction companies**

The biggest challenge facing construction companies throughout the world is the ability to adapt and respond quickly to change, which has led to survival problems for most construction companies (Enshassi, Mohamed & Abushaban, 2009). There have been many studies conducted to identify factors that are affecting construction projects, and these vary from skills shortage, poor project execution, poor leadership and incompetence of contractors to simply a bad attitude towards service (Enshassi, Mohamed & Abushaban, 2009). Stakeholder engagement plays a significant part in the performance of construction projects, the major challenge being the number of stakeholder who get involved in a construction project. According to Enshassi, Mohamed and Abushaban (2009), some of these stakeholders include owners (clients), contractors, consultants and regulators. However, as the construction industry grows more stakeholders need to be considered, including shareholders, the community, subcontractors and suppliers.

**Survival and growth of construction companies**

The growth of firms is an important indicator of a thriving economy (Bakar, Tabassi, Razak & Yusof, 2012). In their research "Key Factors Contributing to Growth of Construction Companies: A Malaysian Experience", Bakar, Tabassi, Razak and Yusof (2012) concluded that most firms have multiple objectives for sustaining their business endeavours, and that in the short-term profit maximisation is the focus, while in the long term the focus changes to growth performance of the company. In contrast, Chakravarthy and Lorange (2008), in their book *Profit or Growth? Why You Don't Have To Choose*, admit that there is often tension between revenue growth and increased profitability, as well as between short-term gains and sustainable long-term performance, but concluded that profit and growth are both attainable in the short and long term.

Angelos (1984) further discussed nine critical factors to be considered when operating in the construction industry, namely: technology changes, skilled labour, trade unions, productivity, government influence, business

cycles, concentration, competition and inflation. Angelos emphasised that companies which survive and grow must be able to manage the critical factors in their industry to their advantage. Considering these factors, it is therefore of interest to examine the survival and growth of South African construction companies which have to operate in an environment that is experiencing the following: rapid technological changes, an influx of new entrants in the industry which requires constant adaptation of business strategies, an economy which has a skills shortage and is mostly affected by the brain drain, an economy that is growing at a very slow rate, the currency fluctuation and drought that are pushing up inflation, continuous labour unrest and an unstable political climate. The management of the nine critical factors for South African construction companies might prove to be key to their survival and growth in both the short and long term.

**Purpose of the study**

The main purpose of this study was to identify positive and negative factors that affect sustainable profitable growth for electrical construction companies in South Africa.

**Problem statement**

To identify business factors affecting sustainable profitable growth for high voltage construction companies in South Africa.

**Significance of the study**

Several studies have been conducted in the field of South African civil engineering construction companies, ranging from survival and growth by George (1984), to insolvencies among civil engineering enterprises by Rwelamila, Lobela and Kupakuwana (2004). Although there are many similarities within the civil engineering and high voltage engineering construction disciplines, their scope of execution is different and it is thus significant to understand the factors that affect sustainable profitable growth in high voltage construction companies specifically.

This study was intended to provide awareness and establish a strategic direction for senior management within the high voltage construction industry in South Africa. This strategic direction was established by understanding the factors that are affecting profitable growth in this industry and positioning their organisations to use the same factors to their competitive advantage.

**Delimitations of the study**

This study was confined to high voltage construction companies that are operating, participating in tenders and executing projects within South Africa and across all nine provinces; any revenues or factors outside South Africa were not considered. The study also drew its assumption from the performance of the construction companies that are registered with CIDB. Companies with active registration status at the time of the study were considered and those that were de-registered, suspended and/or

had expired membership were not considered for this work. There is a wide range of high voltage construction companies registered with CIDB, and for this reason the study focused on companies that are registered under category 8 and 9EP. A company registered under 8EP is eligible to tender and execute projects between R40 million and R130 million, whereas a 9EP-registered company is eligible to execute projects above R130 million without limit in the electrical infrastructure industry. The latter are classified as large established companies with a proven track record in the industry. For this reason, this work did not consider companies that registered below the category of 8EP, which are eligible to tender and execute projects less than R40 million and are classified as SMMEs according to the construction sector codes. It is also understood that not all companies registered under the 8 and 9EP categories with CIDB are actively participating in the high voltage construction industry, and for this reason these contractors were excluded from this study. It is difficult to identify such contractors at the inception stage; however, they were identified during the qualitative survey stage. Although the study seeks to survey companies within the nine provinces of South Africa, according to CIDB, contractors registered under the 8 and 9EP categories with an active status are limited to six provinces:

- Gauteng
- Eastern Cape
- Free State
- Western Cape
- Mpumalanga
- KwaZulu-Natal

The study was further limited to contractors who are active within the substation, overhead powerline and renewable balance of plant construction segments, which excluded contractors who are active in power station construction.

**RESEARCH METHODOLOGY**

Fuzzy Cognitive Mapping (FCM) methodology was used in this work in order to identify factors that are affecting sustainable profitable growth in the high voltage construction sector. FCMs are qualitative alternative approaches to a dynamic system, where the gross behaviour of a system can be observed quickly and without the services of a research expert (Aguilar, 2005). This method allows the use of qualitative simulation of the system and experimentation with the model. Fuzzy cognitive methods were originally used to explain political decision-making processes (Aguilar, 2005). Over the years, they have found favour in theoretical and applied contexts which span from hard to soft science. This method is flexible and is appropriate in finding or drawing a range of conclusions about the belief system of groups or individuals (Gray, Zanre & Gray, 2014). FCM forms a representation of the expert's knowledge

in an explicit manner in order to represent a complex system or even a major problem to reflect in a more easily understood way. FCM as a representation of mental models is divided into two categories. The first is traditional expert knowledge, which encompasses applications such as risk assessment, work efficiency and performance optimisation, strategic deterrence and crisis management, scenario/policy assessment, spatial suitability and prediction mapping, and environmental modelling and management (Gray, Zanre & Gray, 2014). The second category of FCMs represent the mental models from non-Western experts and are mostly applied in planning and management decision-making. These latter FCM models are used to gain an understanding of how stakeholders internally construct their understanding of the world or an issue of interest (Gray, Zanre & Gray, 2014). FCM can describe different aspects of the behaviour of a complex system in terms of simple concepts (Papageorgiou & Kontogianni, 2012), each of which represents a characteristic of the system and in turn interact with one another, thus displaying the dynamics of the system. FCMs were first introduced by the work of Kosko (1986), which were signed directed graphs representing casual reasoning and computation reference processing, thus exploiting a symbolic representation for the description and modelling of the system (Papageorgiou & Kontogianni, 2012).

In the context of FCMs theory, the concept's fuzzy value denotes the degree to which the concept is active in the general system, such that concept values range between [0, 1] and the weights of the arcs are in the interval [-1, +1] (Papageorgiou & Salmeron, 2013). The weights of the edges show the degree of casual influence between the concepts and they are usually assigned linguistically by the industry expert (Papageorgiou & Salmeron, 2013). The positive weights are reinforcing, while the negative weights are decreasing.

FCM concepts are represented by a Matrix C, while the activation levels of individual concepts are represented by a Matrix A. Another matrix that needs to be considered is W, which represent the matrix of weights with each element denoted by $W_{ij}$, which in turn indicates whether the relationship between the concepts is directed or inverse, essentially highlighting the influence of concept Ci on Cj (Hester, 2015). On the other hand, it must be noted that the direction can also be inverse, such that Cj influences Ci. This can be represented by $W_{ji}$, though an important point to note is that $W_{ij}$ is not equal to $W_{ji}$ (Mpelogianni, Marnetta, & Peter, 2015). As such,

- $W_{ij} > 0$ indicates an increase or decrease in the value of $C_i$ which causes the same increase or decrease in $C_j$. This is indicative of a positive causality between the two concepts.

- $W_{ij} < 0$ indicates an increase or decrease in the value of $C_j$ which causes the same increase or decrease in $C_i$. This is indicative of a negative causality between the two concepts.
- $W_{ij} = 0$ indicates no interaction between the two concepts, $C_i$ and $C_j$.

A representation of a simple FCM is shown in Figure 1 below.

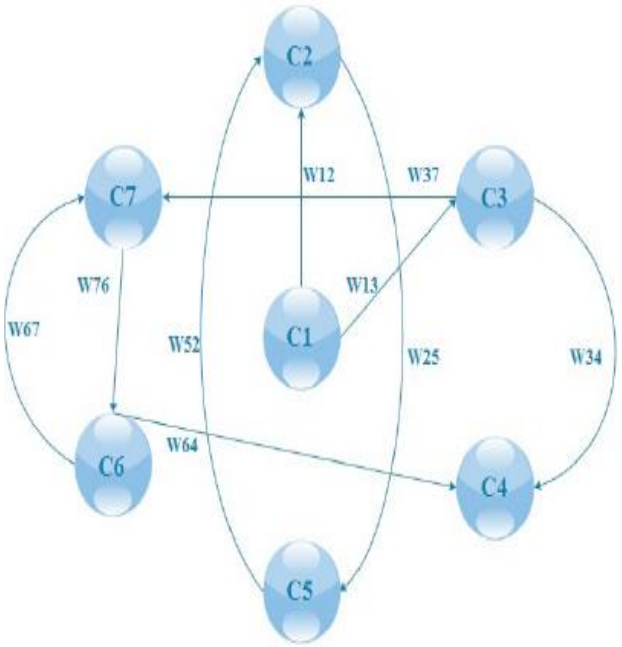



**Figure 1: Simple Fuzzy Cognitive Map (Vergini & Groumpos, 2016)**

According to the conventional FCM theory the amount of influence between $C_i$ and $C_j$ is signified by the absolute value of $W_{ij}$ (Vergini & Groumpos, 2016). This conventional relationship is represented by equation 1.

$$C_i^{(k+1)} = f(C_i^{(k)} + \sum_{j=1, j\neq i}^{n} C_i^{(k)} w_{ji}) \qquad (1)$$

Where $w_{ji}$ is the weight of the arc connecting concept $C_j$ to concept $C_i$, and the value of $C_i$ on each concept is influenced by the values of the concepts nodes $C_j$ that are connected to it (Vergini & Groumpos, 2016).

The function $f$ in equation 1 is the sigmoid function which is expressed by equation 2.

$$f = \frac{1}{1+e^{-\lambda x}} \qquad (2)$$

FCMs have performed an integral role in the past decade, the application of which is diverse and cuts across scientific areas, social issues and politics, management decisions, engineering and technology, including the predictions of environmental changes (Papageorgiou & Salmeron, 2013).

Stacey (2016) in his article, Semi- quantitative System Analysis Using Fuzzy Cognitive Maps argues that the conventional formulation and analysis of a FCM is based on the concept the value of the maps nodes are recalculated by the summation of the weighted influences on the node, a sigmoid function is applied in order to limit the values from going outside the fixed range (Stacey, 2016). Stacey (2016) further points out that the conventional integrative FCM analysis assumes that all systems are either stable, marginally stable or never stable, system FCM nodes limit equally and input nodes are moderated (Stacey, 2016). However, it is to be noted that in the real-world systems can go

unstable, thus the validity of the analysis remains questionable (Stacey, 2016). Further an unstable system will inevitably respond to the instability, such response may necessitate the moderation of relationships between existing elements of the system, the common limiting transformation function across the nodes remains questionable in turn the validity of the conventional analysis (Stacey, 2016).

Stacey (2016) thus propose an alternative formulation of the FCM model, which attempts to eliminate the problems identified by the conventional formulation. In this formulation, a clear distinction is established between input nodes and response nodes (Stacey, 2016). The steady state condition is calculated using equation 3 (Stacey, 2016) .

$$Y_{ss} = T.S\,(1 - B)^{-1} \qquad (3)$$

This work adopts Stacey (2016) alternative formulation of FCM. A FCM model derived from the findings of Stacey (2016) is used to simulate the data from the survey respondent, depicted by figure 7 to 17.

FCMs can be used for several purposes, however only four are mentioned in Papageorgiou and Salmeron's (2013) work, namely: explanatory, prediction, reflective and strategic. The first, explanatory focuses on understanding the reasons for decisions and actions, whereas the second, predictive reasons is based on using FCMs to predict the future descisions and actions. Reflective, which is the third function mentioned in their work helps decision-makers ponder over their representation of a given situation in order to ascertain its adequacy and possibly prompt the introduction of any necessary changes. The fourth funtion, and this is most applicable for this work, is the strategic use of FCM, a function based on generating a more accurate description of a complex situation (Papageorgiou & Salmeron, 2013).

In their research titled "Customer Satisfaction Fuzzy Cognitive Map in Banking Industry", Nasserzadeh et al (2008) concluded that even though there are many qualitative techniques to analyse the structured problems, they are still not sufficient. However, other studies found FCM to be very useful in their study (Nasserzadeh, Jafarzadeh, Mansouri, & Sohrabi, 2008). Choi, Lee and Irani (2016) also used FCM in their work, "Big data-driven fuzzy cognitive map for prioritizing IT service procurement in the public sector" and found that the FCM was useful, but that the existing FCM studies using historical time series data use traditional learning approaches such as Hebbian learning, genetic algorithms and decision trees that have limitations in scalability (Choi, Lee, & Irani, 2016). Gray et al (2015) also used FCM in their research, using fuzzy cognitive mapping as a participatory approach to analyse change, preferred states and perceived resilience of social-ecological systems, and found that the

FCM approach resulted in shared participation in management decision-making. They also found that FCM provides the opportunity to help stakeholders participate in management decisions (Gray, et al., 2015). FCM was also used by Cole and Persichitte (2000) in their work, "Fuzzy Cognitive Mapping: Applications in Education" and they concluded that by combining the capability of fuzzy logic to represent soft knowledge with dynamic model capabilities, the FCM framework introduces tremendous potential (Cole & Persichitte, 2000). In addition, White and Mazlack (2013) used FCM in their work, "Analysing the impact of social factors on homelessness: A Fuzzy Cognitive Map approach", and concluded that FCMs are a viable alternative for conceptualising homelessness and that a literature search of peer reviewed, academic literature is a reasonable foundation upon which to build the model (Mago, et al., 2013)

It is with this view that FCM remains a suitable method for this research as the objective is to understand how stakeholders construct their understanding of the factors that are affecting sustainable profitable growth for construction companies.

Moreover, FCMs are easy to build and parameterise, flexible in representation and simple to use. The flexible nature of FCMs allows for different expert and stakeholder views to be incorporated.

As a generic model, FCM relies on several assumptions, namely: that the concept activation values are updated simultaneously at the same rate, and that the casualties among the concepts are always in effect (Papageorgiou & Salmeron, 2013).

**Research Design**

A descriptive research design is used to provide a picture of a situation as it naturally happens (Burns & Grove, 2003). For this reason, this research utilised a descriptive research design in the form of a survey of selected experts within the electrical construction industry to establish common factors that are affecting their profitable growth. Descriptive design is mainly used to describe concepts rather than to test or predict the relationships between the different concepts.

A survey was used to establish a group's view in the identification of key domain concepts, casual relationships amongst these concepts and the estimation of the casual relationships' strengths (Stach, Kurgan, & Pedrycz, 2003).

The advantage of using this design is that it gives the researcher the ability to collect data accurately and in a structured manner.

The survey was used to determine the concepts that formed part of the FCM map, and the survey questions are outlined in Appendix A. The research was limited to construction companies in operation and generating revenue within South Africa. These companies were further limited to electrical construction companies that

are active in the high voltage industry and are registered with CIDB under categories 8 and 9EP. Currently there are 45 companies registered under category 8EP and 30 companies registered under category 9EP. It must be noted that this list excluded companies which are deregistered and/or companies with membership that is discontinued. Furthermore, the number of targeted companies was reduced to four companies, the selection of which was based on their years of experience in the sector, the company size as represented by their turnover and their participation in the active tenders within the past two years. The four companies in which the expert survey was conducted are:

- Consolidated Power Projects,
- Actom,
- Siemens Power Systems, and
- EOH

Survey questionnaire were sent to the following members of the companies' organisational structures, taking into consideration that organisational structure and job titles will vary from company to company:

- Senior managers
    - Business unit managers
    - Programme managers
    - Bid managers
    - Engineering managers
- Middle managers
    - Projects managers
    - Principal engineers
    - Senior engineers
- Junior managers
    - Project Engineers
    - Junior project engineers

The research used a non-probability sampling strategy and convenience sampling. The sampling profile is given by Table 1 below, which further breaks down the sample population to the type of respondent and the envisaged number to be sampled.

**Table 1: Profile of respondents**

| Description of respondent type | Number to be sampled |
|---|---|
| Senior managers | = 4 per company x 4 companies |
| Middle managers | = 5 per company x 4 companies |
| Junior managers | = 5 per company x 4 companies |

An open questionnaire instrument sent to the four companies was used, which was standardised and addressed to the different respondents as identified. The research questionnaire was designed in line with Stach et al's (2003) manual method for the development of FCM models in such a way as to understand

the key concepts, and identification of the casual relationships and strengths amongst these concepts.

used as the transmitter nodes, as shown in Figure 2The codes for the transmitter nodes are set out in Table 2. The codes were used when

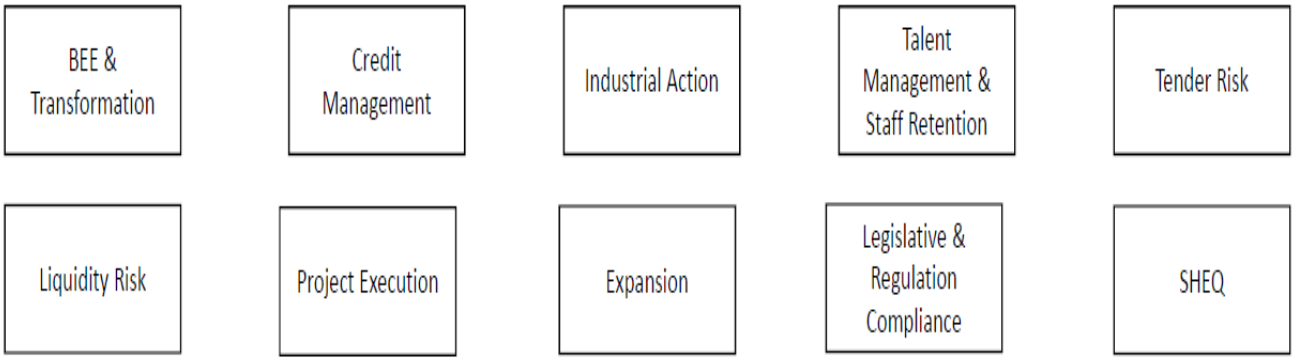



**Figure 2: FCM transmitter nodes**

The questions indicated in Appendix A were designed not to explicitly prompt the respondent to a pattern of answering, but to instead quiz the respondent on how he or she felt about certain relationships which form the driving concepts. The concepts were based on the factors that have been identified as being contributors to sustainable profitable growth as identified in the literature review section, however the questionnaire was designed in such a way that the industry experts also contributed in adding factors that they felt have not been covered by the questionnaire. This approach to the questionnaire design allowed for the implementation of Gray et al's (2014) model, in which a combination of individual and group model collection techniques is discussed. This combination approach assists in the validity of the concepts and their strenghts. The factors that were adentified by PWC's 2015 report were establishing the FCM map and were also utilised for confirming the links and weights of the concepts.

**Table 2: Transmitter Node Codes**

| ***Transmitter Node*** | ***Code*** |
|---|---|
| *BBBEE and Transformation* | C1 |
| *Credit Management* | C2 |
| *Industrial Action* | C3 |
| *Talent Management & Staff Retention* | C4 |
| *Tender Risk* | C5 |
| *Liquidity Risk* | C6 |
| *Project Execution* | C7 |
| *Expansion* | C8 |
| *Legislation & Regulation Compliance* | C9 |
| *SHEQ* | C10 |

The transmitter nodes can be indicated as active (on) and inactive (off) through the use of 1 and 0 respectively. This is essential for plotting the different scenerios.

The active (1) represents a status where the transmitter node exists, as set out in the liturerature review by Papageorgiou and Salmeon (2013). Similary, the inactive (0) represents a status where the transitter node does not exist.

The output shown in Figure 3 is thus defined as two elements: profit (C35) and growth (C36). This is in line with the purpose of this work.




**Figure 3: FCM Output**

**Procedure for data collection**

The schematic representation of research is shown in Figure 4 below.

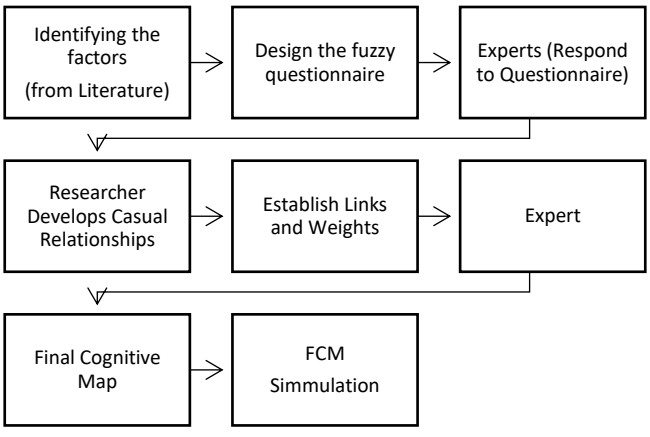



**Figure 4: Schematic Representation of Research**

The first step was to acquire information about the individual companies in the CIDB list, which is the organisational structure of each company, along with the contact details of the identified respondents. Once the contact details were acquired, the questionnaire was sent by email to the respondents and they were given two weeks to respond.

Once the respondents completed the questionnaire, an FCM model was designed to take into consideration the responses from the questionnaire. This addressed mainly the factors that were identified by the respondents as affecting sustainable profitable growth the most. The transmitter nodes were defined and validated by a survey of industry experts, and the FCM output defined. The receiver or normal nodes were defined by the researcher in accordance with Gray et al's (2014) model. The casual relationships between the concepts was established using the researcher's experience and an expert from Consolidated Power Projects, the Managing Director, with over 20 years in the industry. The casual relationships represent the influence of $C_j$ on $C_i$ in accordance with the work of Vergini and Groumpos, (2016), and the final adjacent matrix is shown in Appendix D. The link between the transmitter, receiver and output nodes forms the FCM graph represented in Figure 5. The red arrows represent the negative links, while the green arrows represent the positive links. The casual relationships were established by the researcher and confirmed by

the expert by confirming if the relationship was positive, negative or non-existent, and if the links were strong or moderate in line with Appendix C. The weightings were assigned to each of the links by the researcher and verified by the industry expert, and this formed the adjacent matrix depicted in Appendix D. Once the relationships were established and confirmed, the researcher assigned weights to each of the variables in accordance with Table 3. The expert then had to verify the strength of each of the weights that were assigned to each of the links. The links included the linguistic fuzzy weight which determined the accuracy of the expert's choice.

**Data analysis and interpretation**

The data from the survey respondents was categorised according to their titles or ranking, and the most common factors were grouped together. Once grouped, the remaining factors were ranked according to the percentage of the dominant factors. If these were above 50%, they were included in the study, while any factor falling below 50% resulted in it being excluded from the study.

A mixture of group and individual concept FCM models was used for data analysis, meaning that the concepts were chosen by the researcher with the input of an expert from Consolidated Power Projects. However, the data was ultimately condensed and analysed by only the researcher (Gray, Zanre, & Gray, 2014). FCM was then used to illustrate the complete system using the chosen factors in order to analyse the effects of each factor in a graphical format (Aguilar, 2005). Once the FCM structure was designed and completed, and the variables or factors defined, the structural relationship of these concepts in a matrix allowed three categories to be delineated: driving variable (or forcing component), receiving variable (or impacted component) and ordinary variable (or intermediate component) (Gray, Zanre, & Gray, Fuzzy Cognitive Maps as Representations of Mental Models and Group Beliefs, 2014). These categories were analysed further to establish which of the concepts or factors contributed the most significant influence.

The FCM adjacent matrix was then coded and its structure was analysed using the indices that were derived from the concept weighting. The weighting used ranged from [1; -1] in line with the findings of Papageorgiou and Salmeron, (2013), however the absolute values that were used are shown in Table 3 below. This was an attempt to simplify the concept weighting without compromising the validity and reliability of the study.

**Table 3: Concept Weightings**

| Concept Weighting | Linguistic Weight |
|---|---|

| | |
|---|---|
| -1 | Negatively Strong |
| -0.5 | Negatively Medium |
| 0 | Zero |
| 0.5 | Positively Medium |
| 1 | Positively Strong |

The strength of the casual relationships is defined by the researcher based on the specific industry experience. Mpelogianni, Marnetta and Peter (2015) refer to this strength as $W_{ji}$ and $W_{ij}$, represented by absolute values which are not equal to each other. The range is expanded to [-1; -0.5; 0; 0.5; 1] as represented by Table 3.

The strengths were mapped into the FCM model as depicted by Figure 5, each represented by the absolute value in accordance with the defined range. The FCM output and the transmitted nodes were defined in the introduction and the literature review respectively, while the casual relationships were defined in Appendix B. The table shows the concepts that were used for the casual relationships, the codes that were used in the development of the FCM in order to avoid cluttering and a short description of each of the concepts used. It must be noted that there were a number of definitions that exist for the concepts listed, however for purposes of this work the descriptions in Appendix B were adopted.

**Table 4: Transmitter Node Status**

| ***Transmitter Nodes*** | **On** | **Off** |
|---|---|---|
| *BBBEE and Transformation* | 1 | 0 |
| *Credit Management* | 1 | 0 |
| *Industrial Action* | 1 | 0 |
| *Talent Management & Staff Retention* | 1 | 0 |
| *Tender Risk* | 1 | 0 |
| *Liquidity Risk* | 1 | 0 |
| *Project Execution* | 1 | 0 |
| *Expansion* | 1 | 0 |
| *Legislation & Regulation Compliance* | 1 | 0 |
| *Health, safety and environmental Sustainability* | 1 | 0 |

**Limitations of study**

- The analysis and application of FCM was predominantly done by the researcher and one industry expert with over 20 years in the industry.
- Although FCM provided a powerful tool, there are still issues regarding the interpretation of FCM's artefacts of

individual knowledge and group beliefs (Gray, Zanre, & Gray, 2014).

**Reliability and Validity**

Reliability is concerned with the findings of the research and relates to the credibility of the findings (Welman, Kruger & Mitchel, 2005). Essentially, the aim was to understand if the research would stand up to the closest scrutiny.

The eigenvalues which have a modulus of less than 1 indicate that the system is stable and that and will indeed converge to steady state (Stacey, 2016). The convergence to steady state is reflective of a reliable and valid results. Figure 6 shows a typical stable system with eigenvalues have a modulus of less than 1.

The concepts that were used in the FCM model were tested on a trial respondent before sending it out to selected respondents. The research was compared to findings of Enshassi et al's (2009) research on "Factors Affecting the Performance of Construction Projects in The Gaza Strip", where similar factors are discussed.

- Employing complementary tools, such as standardised surveys may facilitate the assessment of attitudes and beliefs which could be correlated with quantitative FCM structural measurements (Gray, Zanre & Gray, 2014).

- The study was limited to South African-based construction companies and was not reflective of the global perspective.

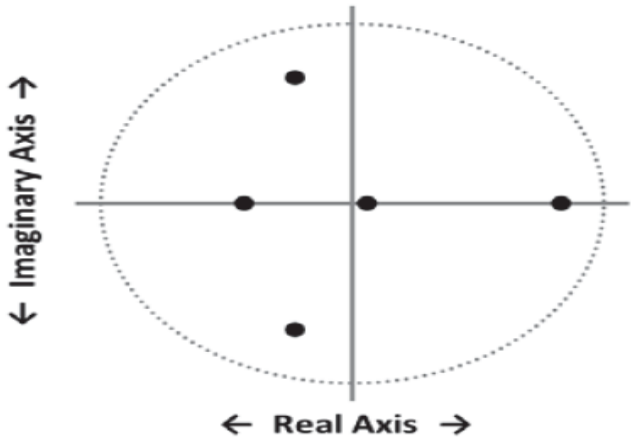



**Figure 5 : Eigenvalues of a stable system (Stacey, 2016)**

The simulation of a stable system with complex eigenvalues showing oscillation and convergence is shown in figure 7 (Stacey, 2016).

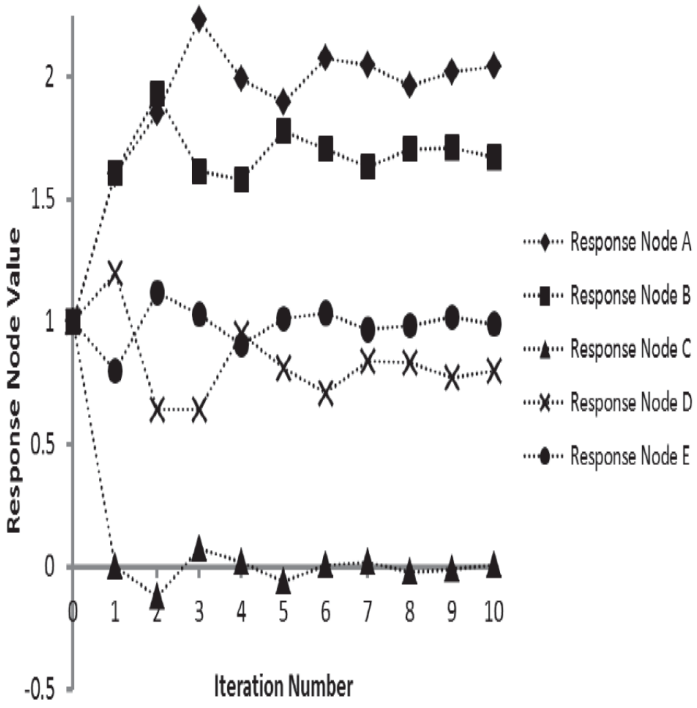



**Figure 6 : FCM Simulation of a stable system (Stacey, 2016)**

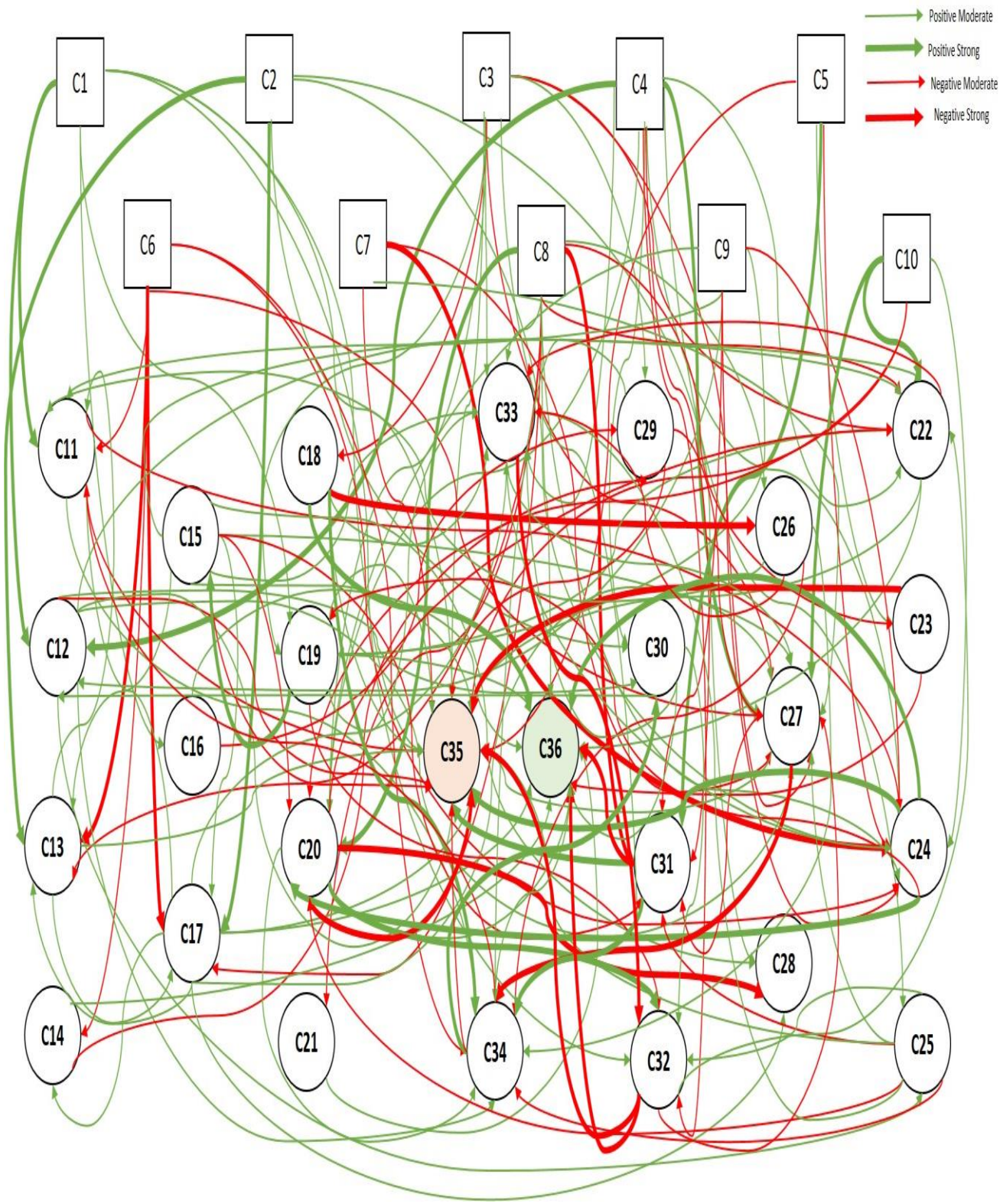



**Figure 7: FCM Map**

**External Validity**

External validity refers to the degree of generalisation from a set of research findings to other people, settings and times (Johnson, 1997). This work was based on construction companies within South Africa, and the concepts and their relationships to FCM were based on South African micro and macro conditions. Therefore, the research cannot be generalised to construction companies outside of South Africa, but can be generalised within the various construction disciplines in the country.

**Internal Validity**

Internal validity refers to the degree to which changes in the dependent variable are due to the independent variable as opposed to something else (Welman, Kruger, & Mitchel, 2005) or some extraneous variable. To promote internal validity in this research, all possible threats to internal validity were eliminated by allowing a group of industry expects to identify the key concepts, and then measure the relationships amongst the concepts and their respective strengths. This was to ensure as far as possible that the extraneous variables were eliminated.

**RESULTS**

The results were split into two, with the first set of results representing the survey outcome which validates the defined transmitter nodes, while the second set of results represent the outcome of the FCM simulation.

**The Survey Results**

The survey open link was sent to 56 respondents, and the target was five companies that are operating in the high voltage construction industry. A total of 43 responses were received, which account for a 77% response rate. Table 5 shows the number of responses. The deviation reflects the spoilt responses, thus only 36 responses remained valid.

**Table 5: Respondent Count**

| *Field* | *Min* | *Max* | *Mean* | *Standard Deviation* | *Variance* | *Responses* |
|---|---|---|---|---|---|---|
| *Total Responses* | 1 | 4 | 2.93 | 0.45 | 0.2 | 43 |

A total of 64% of the respondents were from Consolidated Power Projects, as depicted by Figure 9, with the balance of the respondents being from Siemens Power System, Actom, EOH and Enzani Technologies.

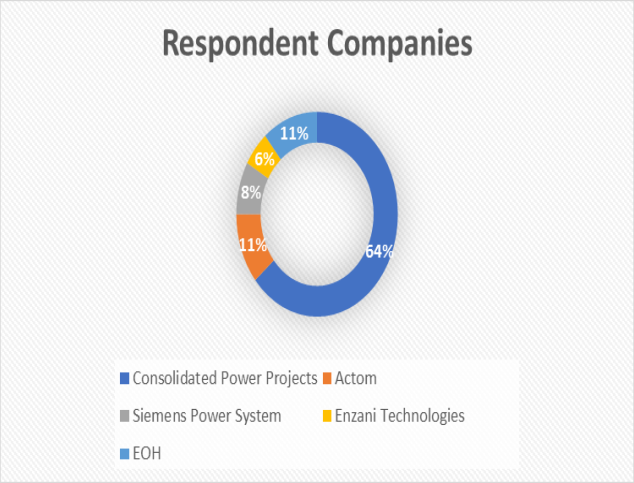



**Figure 8: Respondent Companies**

These companies range from 7EP to 9EP companies, with 86% of the respondents employed by 9EP companies – see Table 6.

**Table 6: Respondent Companies' CIDB grading**

| *Answer* | *%* | *Count* |
|---|---|---|
| *7EP* | 2.33% | 1 |
| *8EP* | 6.98% | 3 |
| *9EP* | 86.05% | 37 |
| *None of these* | 4.65% | 2 |
| *Total* | 100% | 43 |

The responses are further broken down to the targeted experts in terms of their level in their organisations and respective job titles. This is shown in Table 7, where 10 responses came from senior management, 18 from middle management and 8 from junior management. This represents an even spread across the different organisations and the level of expertise used for the research.

**Table 7: Respondents' Profile**

| Senior Managers | Job Title | No. of Responses |
|---|---|---|
| | DIRECTOR - SPECIAL PROJECTS | 1 |
| | Business Unit Manager | 2 |
| | General Manager | 1 |
| | Operations Director | 1 |
| | Business Development Manager | 1 |
| | Senior Service Manager | 1 |
| | Operations Manager | 1 |
| | Commercial Manager | 1 |
| | Senior Project Manager | 1 |
| **Middle Managers** | | |
| | Programme Manager | 1 |
| | Principal Project Engineer | 2 |
| | Project Manager | 9 |
| | Project Engineer | 5 |
| | Senior Project Engineer | 1 |
| **Junior Managers** | | |
| | Project Engineer | 5 |
| | Junior Project Engineer | 1 |
| | Site Supervisor | 1 |
| | Project Co-Ordinator | 1 |
| | **TOTAL RESPONSES** | **36** |

The following results in Table 8 were observed from the survey. The design of the survey was intended to establish how many of the respondents would agree with the researcher's selection of the transmitter nodes and the links amongst the various concepts. This illustrates that the clear majority of the respondents seemed to agree with the proposed concepts. These therefore form part of the receiver or normal node. The transmitter nodes were adopted from the PWC construction report.

The final concepts thus form part of the FCM, as depicted by Appendix B. The casual relationships were then established by the researcher in line with the theory. This was achieved by carefully linking the validated concepts. The weightings were also established by the researcher with the assistance of an

industry expert, which was also in line with the FCM methodology literature theory, with the constraints limits at [-1; 1].

The results were consistent with the model used to establish the FCM map. Although more work needs to be done in terms of establishing a broad view on the concepts, the results were nevertheless sufficient for validating the model. With this established, the next step was to conduct the FCM analysis. The results for the transmitter nodes were consistent with the PWC report discussed under the literature review.

**Table 8: Responses**

| ***Responses*** | ***Percentage*** |
|---|---|
| *Total Sum of Strongly Agree* | 15% |
| *Total Sum of Agree* | 45% |
| *Total Sum of Neither Agree nor Disagree* | 11% |
| *Total Sum of Disagree* | 23% |
| *Total Sum of Strongly Disagree* | 6% |
| *Total Sum of Respondents* | 100% |

**The FCM results**

The convergence was achieved after five interactions. The systems' eigenvalues are thus represented by Figure 11, which represents a stable system thus further validating the results. The results are then shown in the steady state charts. Eleven scenarios are presented as part of the simulation.

Scenario 1 represents the base case – see Figure 10, with all the transmitter nodes in the on (1) position. From this scenario, the top five factors that affect profit and growth negatively are:

- Competition
- Price Pressure
- Working Capital
- Creditors' Payment Management
- Debt Policy

At the same time, the top five factors that affect profit and growth positively are:

- Skills Development
- Remuneration
- Workload
- Education
- Experience

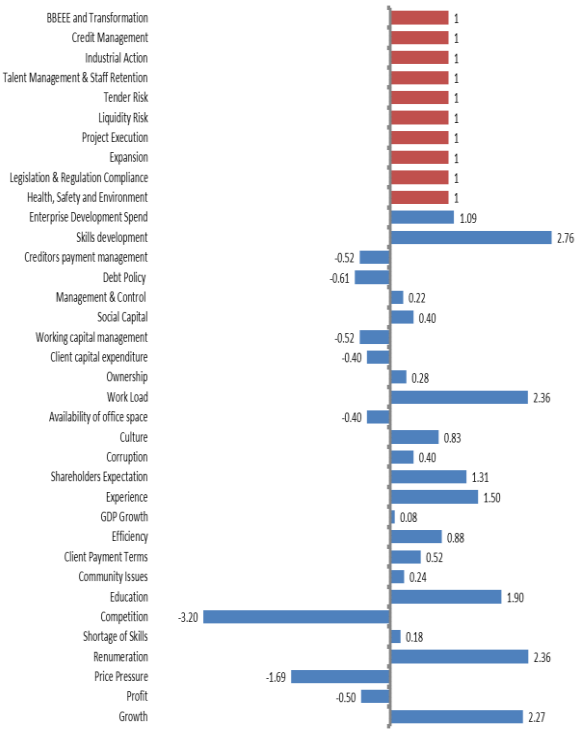



**Figure 9: Scenario 1 – Base Case**

The convergence chart in Figure 11, shows the number of interactions plotted against the various casual relationships for the base case scenario. Convergence was achieved after five interactions. This is illustrative of a stable system in line with the work of Stacey (2016).

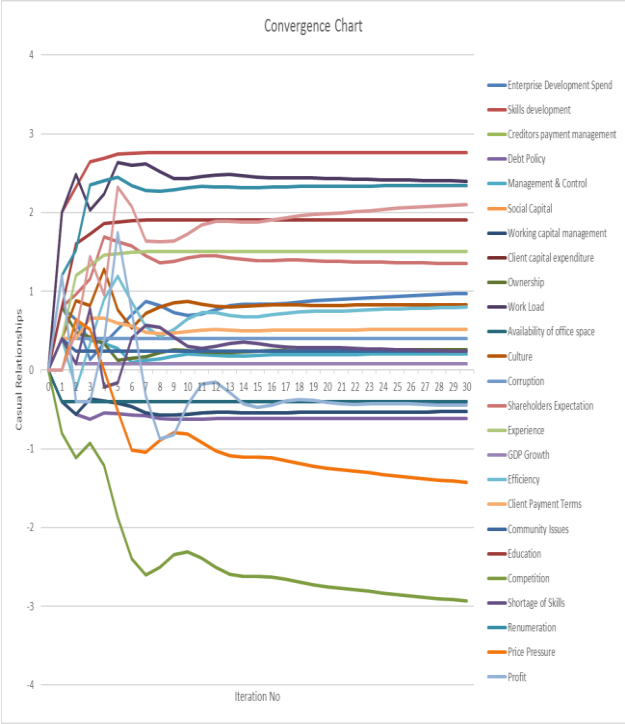



**Figure 10: FCM Convergence Charts**

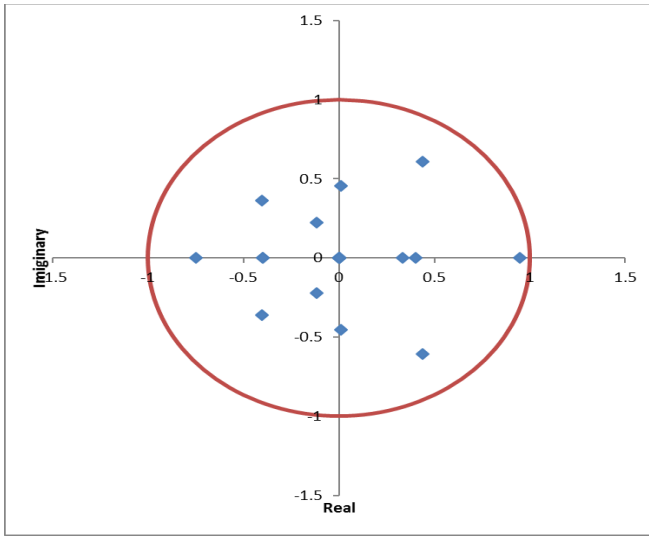



**Figure 11 : Argand diagram of eigenvalues**

Further the results eigenvalues are less than 1 as depicted by figure 12, Argand diagram of eigenvalues. This validate the results as it shown the stability of the system in line with Stacey (2016).

Scenario 2: depicted in Figure 13 illustrates the FCM base case scenario simulated with the BBBEE and transformation transmitter node being switched off (0). The noticeable impact was that competition and price pressure increase drastically. Profit remains stagnant while growth is reduced drastically, or negatively impacted. From this scenario, the management of competition and pricing in the sector becomes critical. The balancing factors remain as enterprise development and skills development.

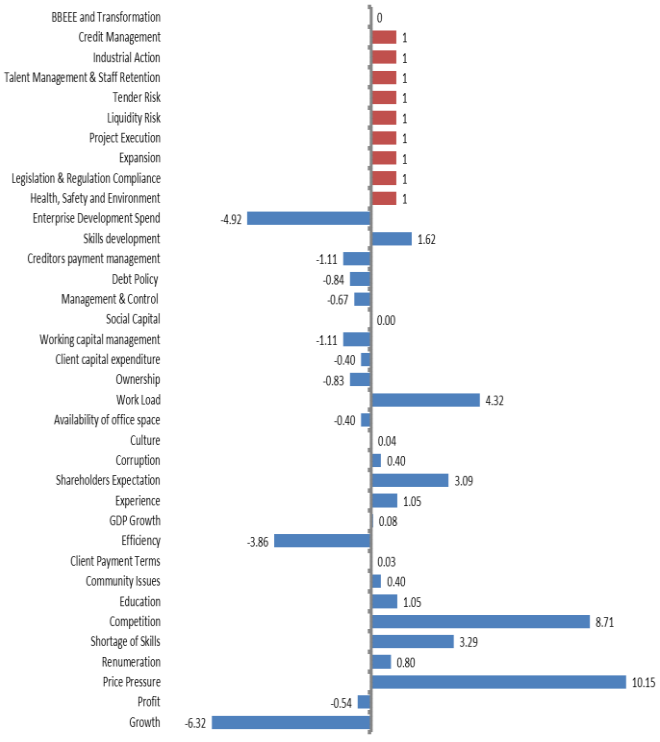



**Figure 12: Scenario 2 – BBBEE and Transformation switched inactive (0)**

Scenario 3: depicted in Figure 14 illustrates the FCM base case scenario simulated with the credit management transmitter node being switched off (0). The noticeable impact was that competition and price pressure decreased drastically, while at the same time Credit Management and Working Capital Management were also impacted. Profit and growth were further reduced, but only slightly. From this scenario, the management of competition and pricing in the sector becomes critical. However, Credit Management and Working Capital Management are also key factors to consider. The balancing factors remain as enterprise development, workload and education.

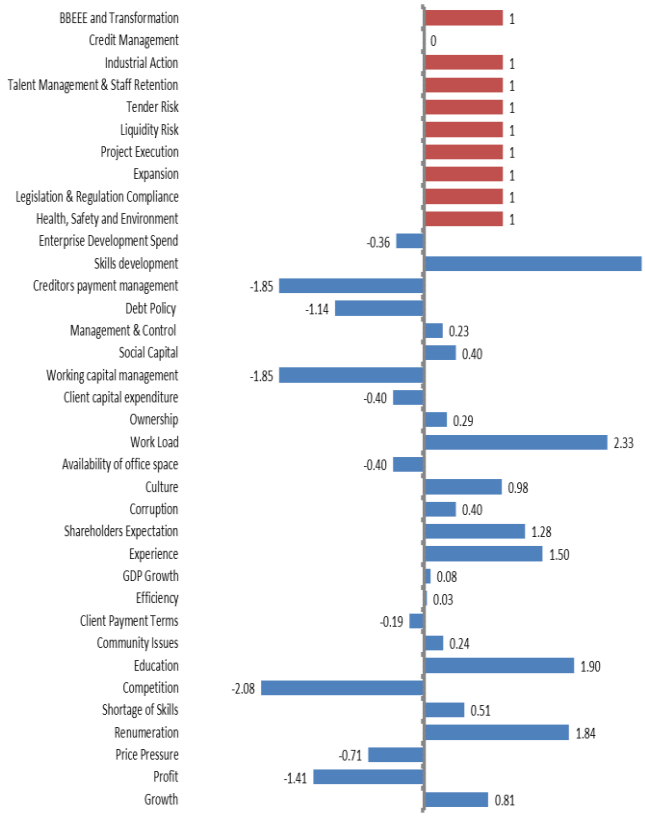



**Figure 13: Scenario 3 – Credit Management switched inactive (0)**

Scenario 4: depicted in Figure 15 illustrates the FCM base case scenario simulated with the Industrial Action transmitter node being switched off (0). The noticeable impact was that competition and price pressure increased slightly, while at the same time Credit Management, Working Capital Management and the debt policy were decreased. There was an improvement in profit, and a slight decrease in growth. From this scenario, the management of Credit Management, Working Capital Management and the debt policy in the sector becomes critical. The balancing factors remain as enterprise development, workload and education.

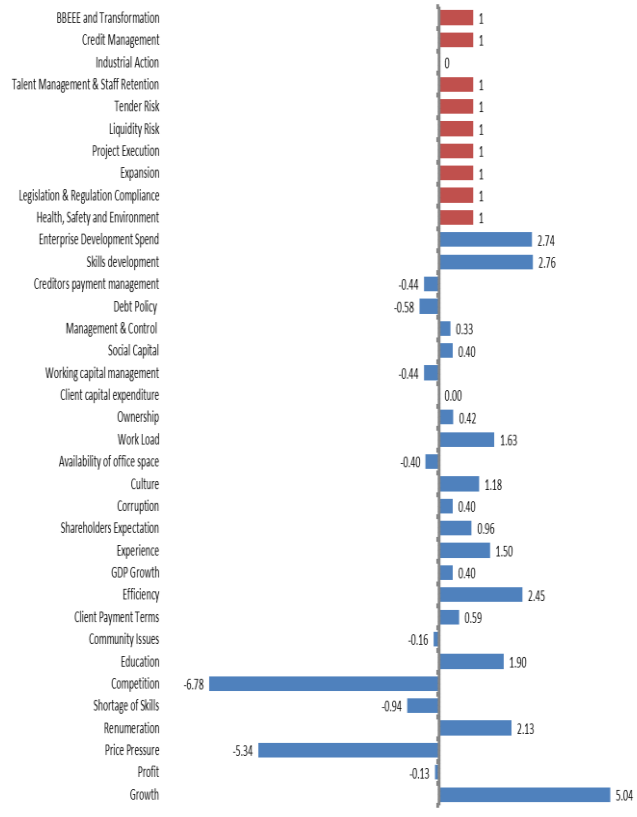



**Figure 14: Scenario 4 – Industrial Action switched inactive (0)**

Scenario 5: depicted in Figure 16 illustrates the FCM base case scenario simulated with the Talent Management and Staff Retention transmitter node being switched off (0). The noticeable impact was that competition and price pressure remained stagnant, while at the same time Credit Management, Working Capital Management and the debt policy were increased. There was a slight improvement in profit and growth. From this scenario, the management of competition and pricing in the sector remains critical. The balancing factors remain as enterprise development, workload and education.

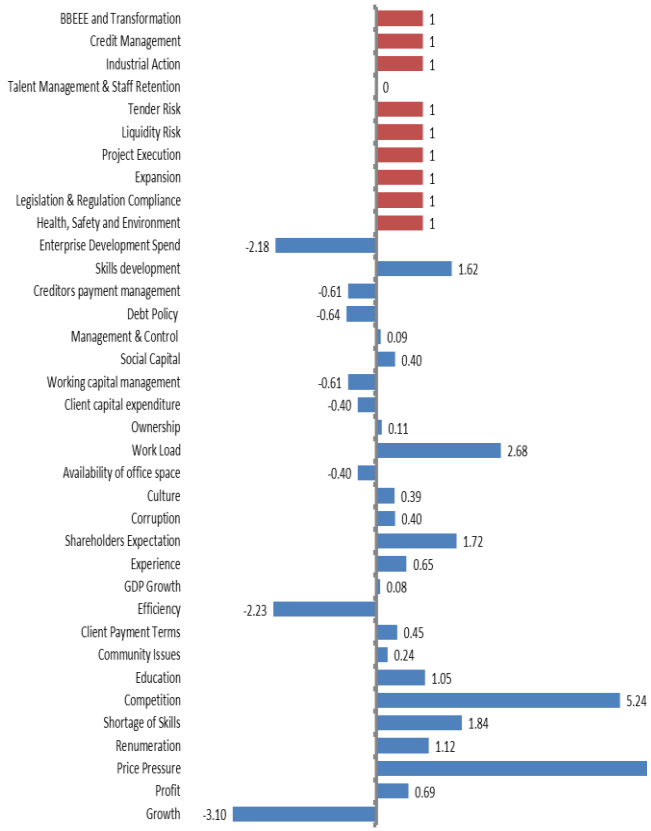



**Figure 15: Scenario 5 – Talent Management & Staff Retention inactive (0)**

Scenario 6: depicted in Figure 17 illustrates the FCM base case scenario simulated with the Tender Risk transmitter node being switched off (0). The noticeable impact was that competition and price pressure increased drastically. Profit was further reduced, while growth improved. From this scenario, the management of competition and pricing in the sector becomes critical. The balancing factors remain as enterprise development and skills development.

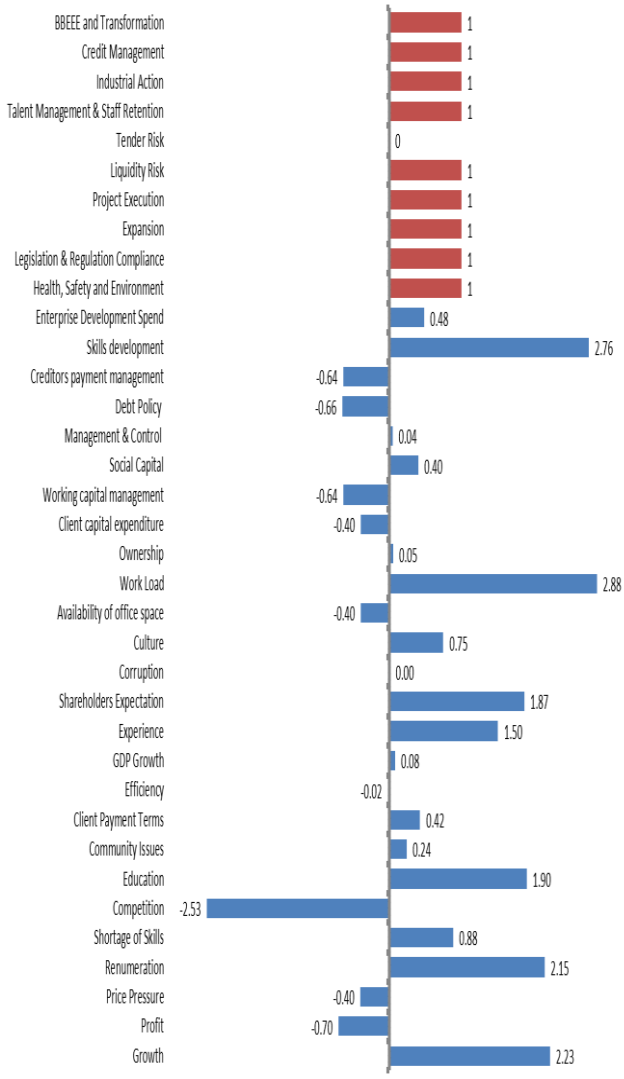



**Figure 16: Scenario 6 – Tender Risk inactive (0)**

Scenario 7: depicted in Figure 18 illustrates the FCM base case scenario simulated with the Liquidity Risk transmitter node being switched off (0). The difference here was that by managing and removing liquidity risk, there was a drastic improvement all around. The price pressure and competition risk were reduced, while at the same time creditors' payment management, debt policy and working capital management were reduced. However, growth was reduced slightly. The balancing factors remain as enterprise development, skills development, remuneration and education. The other factor that shows a drastic swing is price pressure.

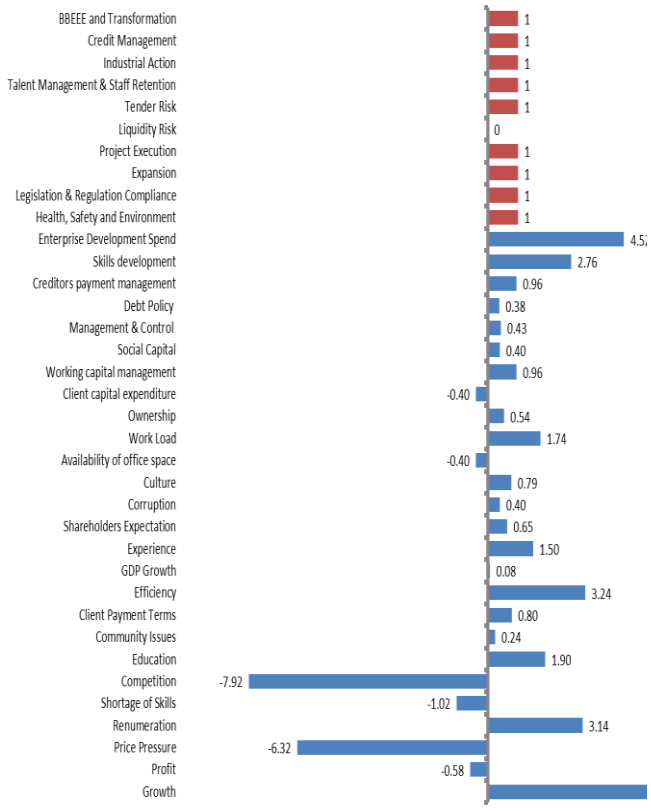



**Figure 17: Scenario 7 – Liquidity Risk inactive (0)**

Scenario 8: depicted in Figure 19 illustrates the FCM base case scenario simulated with the Project Execution transmitter node being switched off (0). A swap in growth and profit was observed in this scenario. There was a drastic increase in profit, while at the same time a drastic decrease in growth. Enterprise development spend needs attention. The balancing factors are price pressure, competition, skills development and workload.

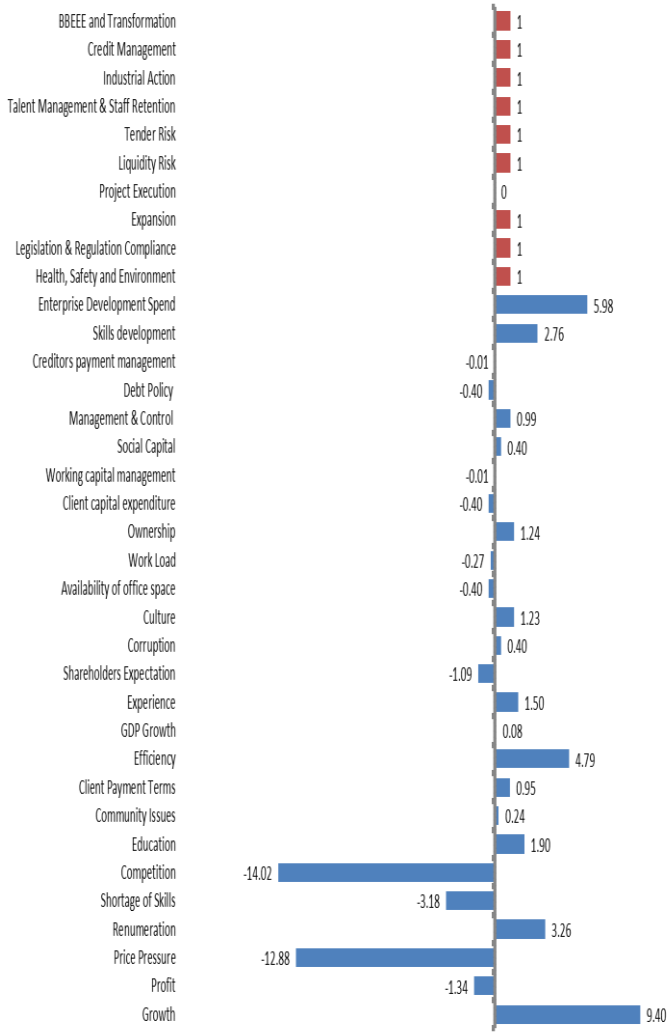



**Figure 18: Scenario 8 – Project Execution inactive (0)**

Scenario 9: depicted in Figure 20 illustrates the FCM base case scenario simulated with the Project Execution transmitter node being switched off (0). A swap in growth and profit was observed in this scenario. There was a drastic increase in profit, while at the same time a drastic decrease in growth. Enterprise development spend needs attention. The balancing factors are price pressure, competition, skills development and workload.

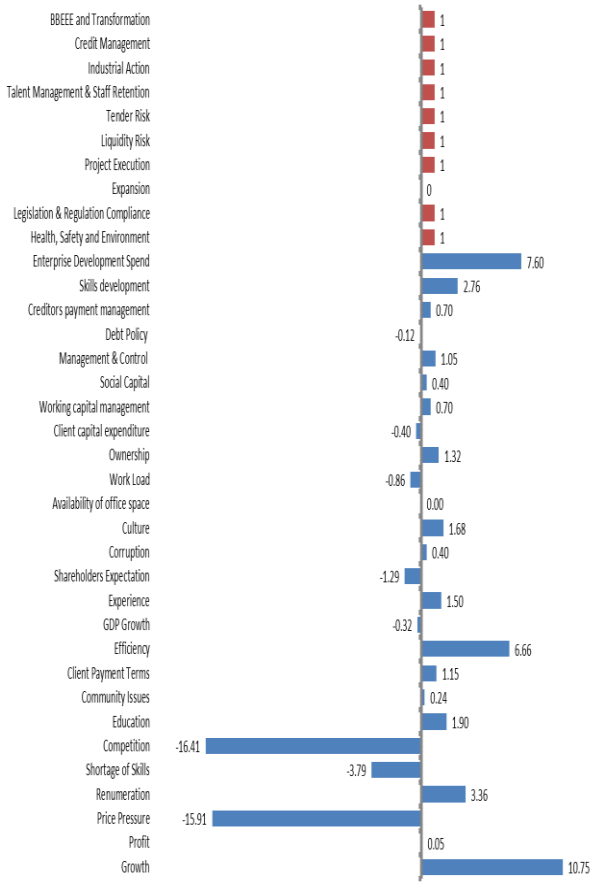



**Figure 19: Scenario 9 – Expansion inactive (0)**

Scenario 10: depicted in Figure 21 illustrates the FCM base case scenario simulated with the Legislation and Regulation transmitter node being switched off (0). The noticeable impact was that competition and price pressure increased drastically. Profit was further reduced, while growth improved. From this scenario, the management of competition and pricing in the sector becomes critical. The balancing factors remain as enterprise development and skills development.

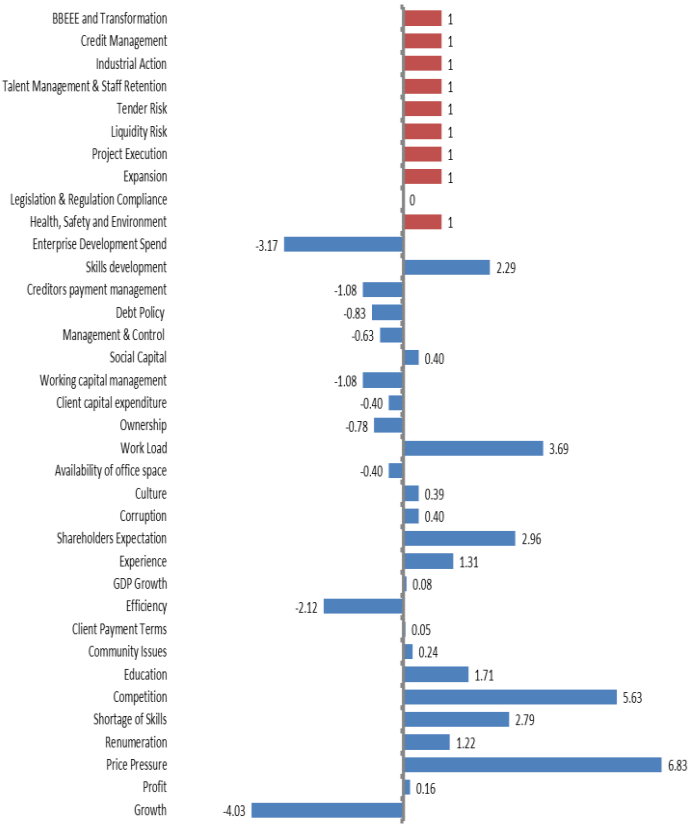



**Figure 20: Scenario 10 – Legislation and Regulation inactive (0)**

Scenario 11: depicted in Figure 22 illustrates the FCM base case scenario simulated with the Health, Safety and Environmental transmitter node being switched off (0). The noticeable impact was that competition and price pressure increased drastically. Profit was further reduced, while growth improved. From this scenario, the

management of competition and pricing in the sector becomes critical. The balancing factors remain as enterprise development, skills development and remuneration.

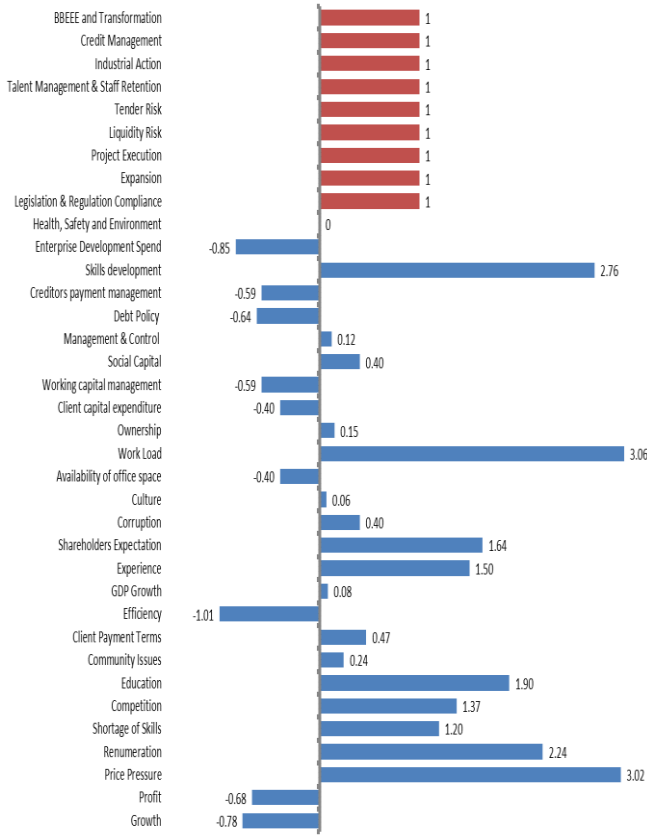



**Figure 21: Scenario 11 – Health, safety and environmental inactive (0)**

The marginal impact graph was plotted in order to establish which of the transmitter nodes contribute to both profit and growth. The marginal impact of each of the factors is depicted in Figure 23. The observation was that there is almost an even distribution amongst the factors. The factors that negatively impact profit are:

- Expansion
- Project Execution
- Liquidity Risk
- Staff Management & Staff Retention
- Industrial Action

On the other hand, the factors that negatively impact growth are:

- SHEQ
- Legislation & Regulation Compliance
- Tender Risk
- Staff Management & Staff Retention
- BBBEE & Transformation

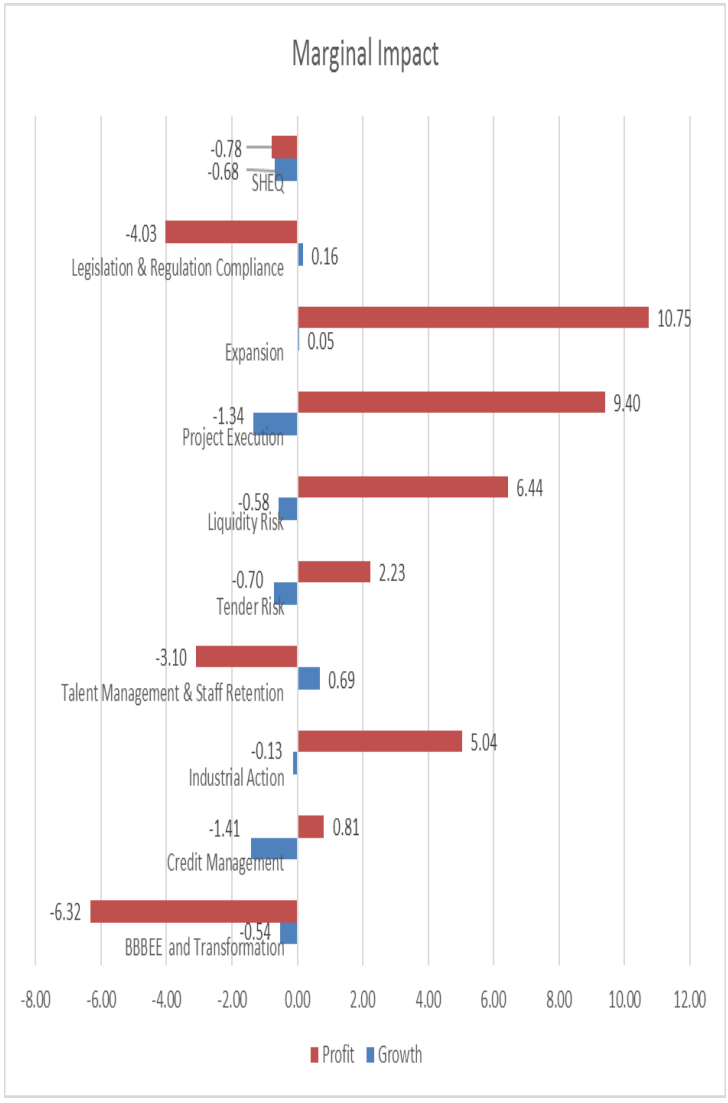



**Figure 22: Marginal Impact**

The top 20% factors that affect both profit and growth are skills development, workload, remuneration, education, experience and shareholders expectations – see Figure 24.

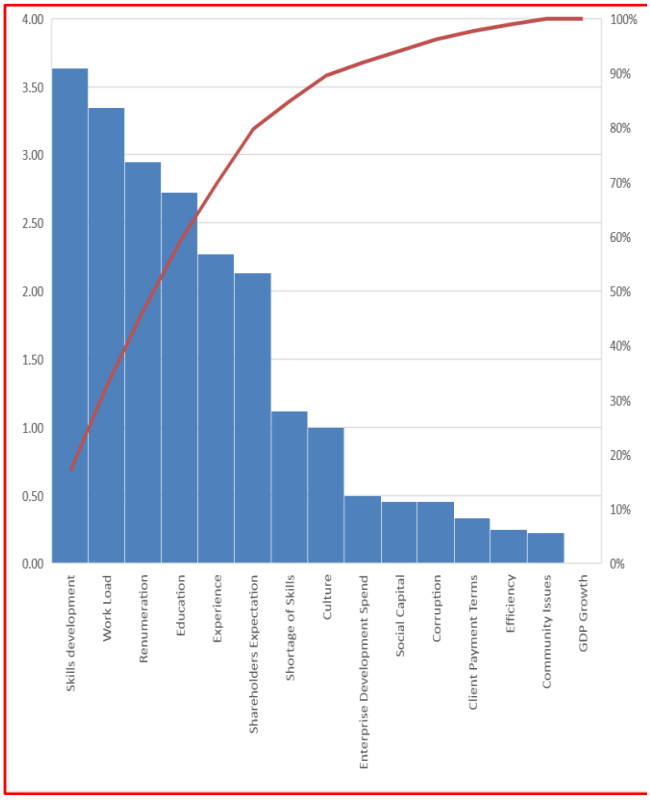



**Figure 23: Major factors affecting growth and profit**

**Results Discussion**

The FCM model was designed and reviewed by the expert using the survey questionnaire in accordance with Stach et al (2003) and Gray et al (2014). The transmitter nodes were thus confirmed to line be in line with the factors that were identified by PWC (2015), Upneck (1984) and the work of Muteswa and Ortlepp (2011).

The casual relationships were derived by the researcher in line with the work of Papageorgiou and Salmeron (2013). Although the casual relationships that have been identified were not limited to the ones used to develop the FCM map, they nevertheless remain sufficient for the purposes of this work. Nasserzadeh, Jafarzadeh, Mansouri and Sohrabi's (2008) approach to establishing the links between the concepts and the individual strenghts was used. An industry expert with extensive experience in the industry reviewed the links and the strenghts in accordance with the work of Jafarzadeh, Mansouri and Sohrabi (2008). A similar approach was also used by Choi, Lee and Irani (2016), Cole and Persichitte (2000) and Mago et al. (2013) in their respective work using FCM. The system stability were tested and found to be in line with Stacey (2016) work, this validates the reliability of the results.

From the simulated results, it was observed that there are factors that positively influence both profit and growth. These are depicted in Figure 23, which illustrates the marginal impact of each factor on both profit and growth accordingly. The 10 scenarios are represented by figures 13 to 22, with all the transmitter nodes in either an active or inactive status. With all the transmitter nodes in active status representing the findings of PWC (2015), creditors' payment management, debt policy, working capital management, client expenditure, availability of office space, competition and price pressure affect profit and growth negatively. A negative impact on profit was also observed, while there

was a positive growth that correlated with the negative factors above, where poor creditor payment management and cash flow management impact the business cash flow negatively and add pressure to the business profitability. This is further exuberated by having a poor debt policy and an over-leveraged business, which also negatively impact profitability. Lastly, the negative price pressure observed, which could be due to a negative client expenditure and high competition, also impact profit negatively. Although growth might not be impacted that much, this could be caused by the construction companies taking or winning work at the wrong price. Upneck (1984) emphasised the importance of winning the right project at the right price, as the consequences of failing to do so could lead to growth in revenues with an erosion in profit margins.

The presence of BBBEE and transformation seem to have a positive effect on profit, but a negative effect on growth. This was observed in the simulation of scenario 2, where the deactivation of BBBEE and transformation led to negative reduction in profit and a slight increase in growth.

Liquidity risk presents a challenge for the profitability of the industry, as observed in scenario 7. By deactivating liquidity risk, there was a huge improvement in profits while the growth of the company remained stagnant. According to Mutti and Hughes (2002), the level of insolvencies in the construction industry is high and is attributed to the lack of financial control, including cash flow and liquidity risk, which is found to be consistent with the findings of this study.

Project execution remains key for the profitability of the company, as observed in scenario 8 by the swing in the profit when project management is deactivated. The strange observation here is that with project execution deactivated, there seems to be a positive effect on profit, and a negative effect on growth. However, Odeyinka, Kaka and Morledge (2003) found that financial planning and seamless execution play a significant part in the survival of construction companies across the globe, which is found to be consittent with the findings of this study.

The factors that marginally impact both profit and growth are depicted in Figure 18. Expansion, project execution, liquidity risk, industrial action, talent management and staff retention all seen to have a negative impact on profit, while SHEQ, legislation and compliance, tender risk, credit management, BBBEE and transformation have a positive effect on profit. The factors that affect growth are SHEQ, legislation and regulation compliance, tender risk, talent and staff management, BBBEE and transformation. Expansion, liquidity risk, industrial action and credit management have a positive effect on growth.

The factors that affect sustainable profitable growth are summarised in Figure 19, namely:

skills development, workload, remuneration, education and experience.

## CONCLUSION

Determining the factors that affect sustainable profitable growth in the high voltage construction industry is important for managers. However, establishing these factors is complicated and vague and it is therefore not easy to quantify them. There are numerous quantitative techniques to analyse the structured problems, but these problems prove to be insufficient for analysing serious problems such as the one under investigation in this study. In this work, FCM was used to establish the factors that affect sustainable profitable growth for high voltage electrical construction companies in South Africa. The FCM model was found to be useful in the establishment of such factors.

Skills development, workload, remuneration, education and experience are considered to be the factors that contribute the most to the establishment of sustainable profitable growth within this industry. The high voltage construction sector is highly specialised, technology driven and attracts a high safety risk. It is therefore found that much emphasis should be placed on skills development and education in order to retain highly-skilled staff. The work experience of staff is also found to be crucial in a technology-driven environment. Safety is a big factor when dealing with electricity and for this reason it is essential that employees are always alert and stress free. To ensure this, managing workload and remunerating the staff well can contribute positively towards safety and reducing downtime. This seems to be in line with the literature that forms part of this study. Finally, the study was limited to factors which were established from the work of PWC, therefore further research is necessary in order to take a broader view of the factors that affect the industry's profitable growth.

## MANAGEMENT RECOMMENDATIONS

An investment in skills development is critical in order for management to develop internal capabilities, while the close management of workload is also critical for management in order to mitigate the effects of brain drain and staff motivation in the sector. This could be complimented by a good remuneration for the staff. Management should also focus on promoting a culture of education in their companies as well as hire people with experience in the relevant tasks. The intense competition in the sector is putting much pressure on the pricing levels, as can be seen from the results. This could be because most of the contracts are secured through the tendering process, which by design lead to price competition. Management can look at moving away from tendered contracts and towards negotiated contracts instead. Negotiated contracts place less emphasis on price, and more

emphasis on quality and relationships. It is also recommended that more research should be done in the quest to establish the factors that affect sustainable profitable growth for high voltage electrical construction companies in South Africa.

Further research is recommended in establishing influence of macro business factors on the construction sector. This would be in relation to the factors identified in this work, factors to consider are staff motivation, pricing levels and the high levels of competitions due to the request for quotations (RFQs) system.

**REFERENCE LIST**


Aguilar, J. (2005). Survey about fuzzy cognitive maps papers (invited paper). *International Journal of computation cognition*, 27.

Bakar, H., Tabassi, A., Razak, A., & Yusof, M. (2012). Key Factors Contributing to Growth of Construction Companies: A Malaysian Experience. *World Applied Sciences Journal* , 1295.

Bhutto, K., Griffith, A., & Stephenssn , P. (2004). Integration Of Quality, Health And Safety And Environment Management System In Contractors Organisations. *Association of Researchers in Construction Management*, 1211.

Bowen, P., Edward, P., & Cattell, K. (2012). Corruption in the South African Construction Industry: A mixed methods study. *Association of Researchers in Construction Management*, 521.

Burns, S. N., & Grove, S. K. (2003). *The Practice of nursing research 3rd Edition.* Philadelphia: Philadelphia: Saunders.

Chakravarthy , B., & Lorange, P. (2008). *Profit Or Growth?: Why you don't have to choose.* New Jersey: Wharton School Publishing.

Chibanguza, T. C. (2016). An investigation into sector designation, prescribed in the Preferential Procurement Policy

Framework Act (PPPFA), as a policy instrument for broadening the Transformer industry's industrial base. 10-20.

Choi, Y., Lee, H., & Irani, Z. (2016). Big data - driven fuzzy cognitive map for prioritising IT service procurement in the public sector. *Big data analytics in operations and supply chain management*, 25.

CIDB. (2016). *Construction Monitor ; Supply and Demand Q1* . Construction Industry Development Board.

Cole, J. R., & Persichitte, K. A. (2000). Fuzzy Cognitive Mapping: Applications in Education . *International Journal of Intelligent System*, 23.

Eberhard, A. (2004). *The Political Economy of Power Sector Reform in South AFrica.* Cape Town: UCT GSB.

Gray, S. A., Gray, A., De Kok, J. L., Helfgott, A. R., O'Dwyer, B., Jordan, R., & Nyaki, A. (2015). Using fuzzy cognitive mapping as a participatory approach to analyse change, preferred states, and perceived resilience of social-ecological system. *Exploring Social-Ecological Resilience through the Lens of the Social Science: Contributions, Critical Reflections, and Costructive Debate*, 11.

Gray, S. A., Zanre, E., & Gray, R. J. (2014). Fuzzy Cognitive Maps as Representations of Mental Models and Group Beliefs. *Fuzzy Cognitive maps for Apllied Science and Engineering*, 29.

Gwaya , A. O., Masu, S. M., & Oyawa , W. O. (2014). Development of a Benchmarking Model for construction projects in Kenya. *International Journal of Soft Comtupint and Engineering*, 36.

Hartley, R. (2009). Fighting Corruption in the Australian construction industry: The national code of practice. *Leadership and Management in Engineering* , 132.

Hester, P. (2015). Analysing Stakeholders Using Fuzzy Cognitive Mapping. *Conference Organised by Missouri University of Science and Technology* (p. 94). San Jose: Elsevier B.V.

Johnson, R. B. (1997). Examining the validity structure of qualitative research. *Education Vol. 118 No. 2*, 289.

Mago, V. K., Morden, H. K., Fritz, C., Wu, T., Namazi, S., Geranmayeh, P., . . . Dabbaghian, V. (2013). Analyzing the impact of social factor s on homelessness: a Fuzzy Cognitive Map approach . *Medical Informatics & Decision Making*, 16.

Morledge, R. (2002). A Factor Approach to the analysis of rsiks influencing construction cost flow forecast. *RICS construction and building research*, 10.

Mpelogianni, V., Marnetta, P., & Peter, P. G. (2015). Fuzzy Cognitive Maps in the Service of Energy Efficiency.

*International Federation of Automatic Control* (p. 3). Patra: Elsevier.

Muiruri, G., & Mulinge, C. (2014). Health and Safety management on construction Projects sites in Kenya: A case study of construction projects in Nairobi County. *FIG Congress 2014*, 2.

Muteswa, R., & Ortlepp, K. (2011). Contributing factors to potential turnover in a sample of South African management-level employees. 13.

Mutti, C., & Hughes, W. (2002). Cash Flow Management in construction firms. *Association of Researchers in construction management*, 23.

Nasserzadeh, S. M., Jafarzadeh, M. H., Mansouri, T., & Sohrabi, B. (2008). Customer Satisfaction Fuzzy Cognitive Map in Banking Industry. *Communications of the IBIMA*, 161.

Ntuli, B., & Allopi, D. (2014). Impact of Inadequate Experience and Skill on the Construction Sector in Kwazulu-Natal, South Africa. *Engineering, Technology & Applied Science Research*, 570.

Odeyinka, H. A., Kaka, A., & Morledge, R. (2003). An Evaluation of construction cash flow management approach in contracting organisations. *ResearchGate*, 2.

Olusegun, A. E., Benson , A., & Esther, I. (2011). Corruption in the Construction Industry of Nogeria: Causes and Solutions. *Journal of emerging trends in Economics and Management Science* , 156.

Papageorgiou, E. I., & Salmeron, J. L. (2013, February 1). A Review of Fuzzy Cognitive Maps Research During the Last Decade. *IEEE TRANSACTIONS ON FUZZY SYSTEMS, VOL. 21, NO. 1,*, p. 66.

Papageorgiou, E., & Kontogianni, A. (2012). Using Fuzzy Cognitive Mapping in Environmental Decision Making and Management: A Methodological Primer and an Application. *International Perspectives on Global Environmental Change*, 429 - 446.

PWC. (2015, November 1). Highlighting trends in the South African construction industry . *SA construction 3rd edition* , p. 3.

Short, T. (2004). *ELECTRIC POWER DISTRIBUTION HANDBOOK*. London: CRC Press.

Smallwood, J. J. (2010). Health and Safety and the environment as project paramers. 1.

Smallwood, J., Haupt, T., & Shakantu, W. (2016). *Construction Health & Safety in South Africa: Status and Recommendations.* Pretoria: CIDB.

Stacey, A. (2016). Semi-quantitative System Analysis Using Fuzzy Cognitive Maps. *Proceedings of The 15th European Conference on Research Methodology*

*for Business and Management Studies* (p. 276). London: Kingston Univesity London UK.

Stach, W., Kurgan, L., & Pedrycz, W. (2003). A SURVEY OF FUZZY COGNITIVE MAP LEARNING METHODS. 5.

Sunjka, B. P., & Jacob, U. (2013). Significant causes and effects of project delays in the Niger delta Region Nigeria. *SAIIE25*, 641-4 - 641-7.

Supplier Select. (2014, May 26). *Supplier Select*. Retrieved from What is the difference between an open and closed RFP?: http://www.supplierselect.com/faq/article/106/

Sweet, S., & Pitt-Catsouphes, M. (2010). Talent Pressures and the Aging Workforce: Responsive Action Steps for the Construction Sector. *Industry Sector Report 5.1*, 3-4.

Thomas, J. (2015). Study on Causes and Effects of Employee Turnover in Construction Industry. *International Journal of Science and Research*, 3041.

Upneck, R. G. (1984). Approaches to bidding strategy in the South African construction industry. 63.

Vergini, S. E., & Groumpos, P. P. (2016). A new conception on the Fuzzy Cognitive Maps method. *International Federation of Automatic Control* (p. 301). Patras: Elsevier.

Welman, Kruger, & Mitchel. (2005). *Research Methodology Third Edition* . Cape Town : Oxford Univesity Press.

Zou, P. X. (2006). Strategies for minimizing Corruption in the Construction Industry in China. *Journal of Construction in Developing Countries Vol.11*, 15.

# Appendix A – Survey Questions

| Questions | Sum of Strongly agree | Sum of Agree | Sum of Neither agree nor disagree | Sum of Disagree | Sum of Strongly disagree |
|---|---|---|---|---|---|
| A company's debt policy important for achieving sustainable profitable growth | 4 | 25 | 4 | 2 | 1 |
| A company's growth strategy should be linked to the country's GDP growth. | 3 | 15 | 4 | 11 | 3 |
| A company's Liquidity can affect project execution negatively. | 11 | 13 | 4 | 5 | 2 |
| A company's Liquidity can affect B-BBEE and transformation | 5 | 13 | 7 | 7 | 3 |
| An increase in the number of staff is a good measure of a company's growth | 2 | 17 | 4 | 8 | 4 |
| B-BBEE and transformation causes Industrial action. | 0 | 5 | 7 | 17 | 7 |
| B-BBEE and transformation negatively affect company profitability. | 4 | 6 | 3 | 17 | 6 |
| B-BBEE and transformation negatively affect project execution. | 2 | 4 | 6 | 16 | 8 |
| B-BBEE and transformation stimulates talent management and staff retention | 6 | 13 | 4 | 11 | 1 |
| Compliance with B-BBEE and transformation increases a company's growth. | 2 | 21 | 5 | 5 | 3 |
| credit management increases a company's liquidity. | 11 | 16 | 5 | 4 | 0 |
| Health, safety and environmental sustainability increases a company's liquidity. | 3 | 16 | 3 | 9 | 4 |
| Health, safety and environmental sustainability increases project profitability. | 12 | 38 | 4 | 17 | 1 |
| Industrial actions impedes a company's growth | 7 | 15 | 2 | 7 | 4 |
| IRR (Internal Rate of Return) is a good measure of a projects profitability | 7 | 26 | 2 | 1 | 0 |
| Is EBITDA (Earnings Before Interest Depreciation & Amortization) is a good measure of a company's operational performance? | 3 | 23 | 5 | 4 | 1 |
| Legislative and regulatory compliance reduces tendering margins | 3 | 15 | 3 | 10 | 5 |
| Legislative and regulatory compliance affects a company's liquidity | 3 | 10 | 7 | 12 | 4 |
| NPV (Net Present Value) should be used to decide if a project is viable or not. | 4 | 28 | 4 | 0 | 0 |
| Overspending on project items is normal. | 1 | 4 | 4 | 20 | 5 |
| Paying your suppliers early at a discount better than paying them when payment is due. | 2 | 17 | 6 | 11 | 0 |
| Project markup is a good measure of a projects profitability | 2 | 15 | 5 | 14 | 0 |
| Projects profitability is a good measure of a company's growth | 5 | 19 | 3 | 8 | 1 |
| ROE (Return on Equity) is a good measure of a company's growth or decline. | 7 | 20 | 3 | 4 | 0 |
| Sales/revenue on it's own is good measure of a company's growth | 4 | 17 | 2 | 12 | 1 |
| Talent management and staff retention is key for a company's Growth and expansion. | 17 | 12 | 3 | 2 | 2 |
| Talent management and staff retention increases a company's liquidity | 7 | 14 | 3 | 9 | 2 |
| Talent management and staff retention increases efficiency in projects execution. | 16 | 14 | 2 | 3 | 1 |
| Talent management and staff retention reduces Industrial Action. | 2 | 21 | 3 | 8 | 2 |
| The returns gained on each project should exceed the cost of capital (or WACC). | 5 | 26 | 2 | 3 | 0 |
| **Grand Total** | **160** | **498** | **119** | **257** | **71** |

## Appendix B – Concept Codes

| *Concept* | *Code* | *Definition* |
|---|---|---|
| *Enterprise Development Spend* | C11 | The company's expenditure on developing small and medium enterprises as per BBBEE regulation. |
| *Skills development* | C12 | Spend on skill development and staff training. |
| *Creditors payment management* | C13 | Suppliers' payment terms management. |
| *Debt Policy* | C14 | The company having a clear debt policy, stating the target D/E ratio. |
| *Management & Control* | C15 | The company having an excellent management and control. |
| *Social Capital* | C16 | Management leverage on networks and relationships. |
| *Working capital management* | C17 | The company having a good working capital management. |
| *Client capital expenditure* | C18 | The clients spent on capital projects, thus providing demand. |
| *Employee Ownership* | C19 | Employees having ownership in the company. |
| *Workload* | C20 | Company employees who with high workload. |
| *Availability of office space* | C21 | The availability of the company to expand in the current premises. |
| *Culture* | C22 | The positive culture of the company. |
| *Corruption* | C23 | The existence of corruption in the organisation and the sector. |
| *Shareholders Expectation* | C24 | The companies pressure to meet shareholders expectation. |
| *Experience* | C25 | The work experience of the staff in the sector. |
| *GDP Growth* | C26 | The growth of the country in terms of gross domestic product. |
| *Efficiency* | C27 | The maximisation of asset use to grow revenues while achieving maximum profit. |
| *Client Payment Terms* | C28 | Negotiating good payment terms with clients in order to maintain positive cash flow. |
| *Community Issues* | C29 | The community unrest in areas of construction. |
| *Education* | C30 | The education qualification level of staff. |
| *Competition* | C31 | Competition within the construction sector. |
| *Skill Shortage* | C32 | The shortage of skills in the sector. |
| *Remuneration* | C33 | How well a company pays its staff, would reflect to the level of commitment. |
| *Price Pressure* | C34 | The pricing pressure in the sector due to high supplier and customer bargaining power. |

## Appendix C – Concept Relationship

| *Relationship* | *Positive Relation* | *Negative Relations* | *Strength* |
|---|---|---|---|
| *C1 - C11* | X | | Strong |
| *C1 - C12* | X | | Strong |
| *C1- C16* | X | | Moderate |
| *C1- C19* | X | | Moderate |
| *C1 - C30* | X | | Moderate |
| *C1- C32* | X | | Moderate |
| *C1 - C35* | X | | Moderate |
| *C2 – C13* | X | | Strong |
| *C2 - C17* | X | | Strong |
| *C2 – C24* | X | | Moderate |
| *C2 – C28* | X | | Moderate |
| *C2 – C35* | X | | Moderate |
| *C3 – C18* | | X | Moderate |
| *C3 – C20* | X | | Moderate |
| *C3 – C22* | | X | Moderate |
| *C3 – C24* | | X | Moderate |
| *C3 – C27* | | X | Moderate |
| *C3 – C29* | X | | Moderate |
| *C3 – C32* | X | | Moderate |
| *C3 – C33* | X | | Moderate |
| *C3 – C35* | X | | Moderate |
| *C4 – C12* | X | | Strong |
| *C4 – C20* | X | | Moderate |
| *C4 – C22* | X | | Moderate |
| *C4 – C24* | X | | Moderate |
| *C4 – C25* | X | | Moderate |
| *C4 – C27* | X | | Strong |
| *C4 – C30* | X | | Moderate |
| *C4 – C31* | | X | Moderate |
| *C4 – C32* | | X | Moderate |
| *C4 – C33* | X | | Moderate |
| *C5 – C23* | X | | Moderate |
| *C5 – C24* | | X | Moderate |
| *C5 – C31* | X | | Strong |
| *C5 – C35* | | X | Moderate |
| *C6 – C11* | | X | Moderate |
| *C6 - C13* | | X | Strong |
| *C6 - C14* | | X | Moderate |
| *C6- C17* | | X | Strong |
| *C6- C24* | | X | Moderate |
| *C6 – C27* | | X | Moderate |
| *C6- C34* | | X | Moderate |
| *C7 – C20* | | X | Moderate |
| *C7 – C24* | | X | Strong |
| *C7 – C27* | X | | Moderate |
| *C7 – C35* | | X | Moderate |
| *C8 – C13* | | X | Moderate |
| *C8 – C17* | | X | Moderate |
| *C8 – C20* | X | | Strong |
| *C8 – C21* | | X | Moderate |
| *C8 – C22* | | X | Moderate |
| *C8 – C24* | X | | Moderate |
| *C8 – C26* | X | | Moderate |
| *C8 – C27* | | X | Moderate |
| *C8 – C31* | | X | Strong |
| *C8 – C33* | X | | Moderate |
| *C8 – C36* | X | | Moderate |
| *C9 – C11* | X | | Moderate |
| *C9 – C12* | X | | Moderate |
| *C9 – C19* | X | | Moderate |
| *C9 – C20* | X | | Moderate |
| *C9 – C24* | | X | Moderate |
| *C9 – C27* | | X | Moderate |
| *C9 – C31* | | X | Moderate |
| *C10 – C20* | | X | Moderate |
| *C10 – C22* | X | | Strong |
| *C10 – C24* | X | | Moderate |
| *C10 – C27* | X | | Strong |
| *C10 – C35* | | X | Moderate |
| *C11 – C24* | | X | Moderate |
| *C11 – C34* | X | | Moderate |

## Appendix D - Adjacent Matrix (Base Case)

| Adjacency Matrix | | BBEEE and Transformation | Credit Management | Industrial Action | Talent Management & Staff Retention | Tender Risk | Liquidity Risk | Project Execution | Expansion | Legislation & Regulation Compliance | Health, Safety and Environment | Enterprise Development Spend | Skills development | Creditors payment management | Debt Policy | Management & Control | Social Capital | Working capital management | Client capital expenditure | Ownership | Work Load | Availability of office space | Culture | Corruption | Shareholders Expectation | Experience | GDP Growth | Efficiency | Client Payment Terms | Community Issues | Education | Competition | Shortage of Skills | Renumeration | Price Pressure | Profit | Growth |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BBEEE and Transformation | Transmitter nodes | | 0.80 | 0.80 | | | | 0.40 | | | 0.40 | | | | | | | | | | | | | | | | | | | 0.40 | | 0.40 | | | 0.40 | | |
| Credit Management | | | | | 0.80 | | | | 0.80 | | | | | | | | | | | | | | | 0.40 | | | | 0.40 | | | | | | | 0.40 | | |
| Industrial Action | | | | | | | | | | -0.40 | | 0.40 | | -0.40 | | | | | | -0.40 | | | -0.40 | | | -0.40 | | | 0.40 | | | 0.40 | 0.40 | | | 0.40 |
| Talent Management & Staff Retention | | | 0.80 | | | | | | | | | 0.40 | | 0.40 | | | | | | 0.40 | 0.40 | | 0.40 | | | 0.80 | | | 0.40 | -0.40 | -0.40 | 0.40 | | | | |
| Tender Risk | | | | | | | | | | | | | | | | | | | | | | 0.40 | -0.40 | | | | | | | 0.80 | | | | -0.40 | -0.40 |
| Liquidity Risk | | -0.40 | | -0.80 | -0.40 | | | | -0.80 | | | | | | | | | | | | | | -0.40 | | | -0.40 | | | | | | | | | | -0.40 |
| Project Execution | | | | | | | | | | | | 0.40 | | | | | | | | | | | 0.80 | | | 0.40 | | | | | | | | 0.40 | | |
| Expansion | | | | -0.40 | | | | | -0.40 | | | 0.80 | -0.40 | -0.40 | | | | | | | | | 0.40 | | 0.40 | -0.40 | | | | -0.80 | | 0.40 | | | | 0.40 |
| Legislation & Regulation Compliance | | 0.40 | 0.40 | | | | | | | 0.40 | 0.40 | | | | | | | | | | | | -0.40 | | | -0.40 | | | | -0.40 | | | | | | |
| Health, Safety and Environment | | | | | | | | | | | -0.40 | | 0.80 | | | | | | | | | | 0.40 | | | 0.80 | | | | | | | | 0.40 | | |
| Enterprise Development Spend | Normal and Receiver Nodes | | | | | | | | | | | | | | | | | | | | | | -0.40 | | | | | | | | | | 0.40 | -0.40 | | |
| Skills development | | | | | | | | | | | | | | 0.40 | | | 0.40 | | | | | | | 0.40 | | 0.40 | | | 0.40 | | -0.40 | | 0.40 | 0.40 | | |
| Creditors payment management | | 0.40 | | | | | | | 0.40 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Debt Policy | | | | | | | | | | | | | | | | | | | | | | | | | | | -0.40 | | | | | | | | | 0.40 |
| Management & Control | | | | 0.40 | | | | | 0.40 | | | -0.40 | | 0.40 | | | | | | | | | | | | | 0.40 | 0.40 | | -0.40 | | 0.40 | -0.40 | 0.40 | 0.40 |
| Social Capital | | | | | | | | | | | | | | | | | | | | | | | | | | | | -0.40 | | | | | | | | 0.40 |
| Working capital management | | 0.40 | | 0.40 | 0.40 | | | | | | | | | | | | | | | | | | | | | | 0.40 | 0.40 | | | | 0.40 | | 0.40 | 0.40 |
| Client capital expenditure | | | | | | | | | | | | | | | | | | | | | | | | | 0.80 | | | | | | 0.40 | 0.80 | 0.40 | 0.80 |
| Ownership | | | | | | 0.80 | | | | | | | | | | | | | | 0.40 | | | | | | | | | | -0.40 | 0.40 | | 0.40 | 0.40 |
| Work Load | | | | | | | | | | | | | | | | | | | | -0.40 | | | | | | -0.80 | | | | 0.80 | | 0.40 | -0.80 | -0.40 |
| Availability of office space | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.40 |
| Culture | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | -0.40 | | | 0.40 | 0.40 | |
| Corruption | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | -0.80 | -0.40 | |
| Shareholders Expectation | | | | | | | | | | -0.40 | 0.80 | | | | | | | | | | | | | | | | | | | | | | 0.80 | 0.80 | |
| Experience | | | | | | | | | | | -0.40 | | | | | | | | | | | | | | | 0.40 | | | -0.40 | 0.40 | 0.40 | -0.40 | 0.40 | | |
| GDP Growth | | 0.40 | | | | | | | | | | | | | | | | | | | | | | | | | | | | -0.40 | -0.40 | | | 0.80 | |
| Efficiency | | | | | | | | | | | | | | | | | | | | | | | | | | | | | -0.40 | | | -0.80 | 0.40 | | |
| Client Payment Terms | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Community Issues | | | | | | | | | | | | | | | | | | | | | | | | | | -0.40 | | | | | | 0.40 | -0.40 | | |
| Education | | | 0.40 | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.40 | 0.40 | | | 0.40 | |
| Competition | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.80 | 0.80 | -0.80 | |
| Shortage of Skills | | | | | | | | | | | | | | | | | | | | | 0.40 | | | | | -0.40 | | | | | | | -0.80 | -0.80 | |
| Renumeration | | | | | | | | | | | | | | | | | | | | | | | 0.40 | | | 0.40 | | | | -0.80 | | | | | |
| Price Pressure | | -0.40 | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.80 | | | | -0.40 | 0.40 | |
| Profit | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Growth | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Steady State:** | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.09 | 2.76 | -0.52 | -0.61 | 0.22 | 0.40 | -0.52 | -0.40 | 0.28 | 2.36 | -0.40 | 0.83 | 0.40 | 1.31 | 1.50 | 0.08 | 0.88 | 0.52 | 0.24 | 1.90 | -3.20 | 0.18 | 2.36 | -1.69 | -0.50 | 2.27 |