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The Role of Consultants in Ensuring Compliance to Engineering Standards in Steel Fabrication Projects

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0410666W

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

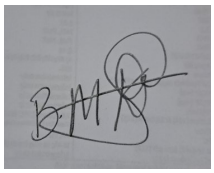
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DECLARATION

I, Buhlebezwe Khumalo, 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.



Buhlebezwe Khumalo

Signed at Johannesburg

On the 21 day of June 2023

DEDICATION

I dedicate this research to my family, friends and all those who work tirelessly on steel fabrication and erection projects to make South Africa and Africa a better place.

Special thanks to Abenathi Khumalo for always asking relevant questions to keep progression of this research exciting.

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I acknowledge assistance from my Supervisor Dr Peterson Owusu Junior, support from my family and guidance from Wits Business School. I would also like to acknowledge my current employer Onderstepoort Biological Products for allowing me to use all platforms available to collect data.

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ABSTRACT

This research paper investigates the role played by engineering consultants on steel fabrication projects to provide compliance to engineering standards. Complying to all engineering standards increases chances of considering the project as successful. With significant number of engineering project that have failed, it was important to investigate the client's satisfaction on the work conducted by engineering consultants. Criteria such as importance of engineering consultant, value added by engineering consultants and the percentage amount to be paid consultants were used to investigate clients' satisfaction on the work done by engineering consultants on steel fabrication projects. Literature review revealed that engineering consultants need to keep up with latest technology to be able to comply with the engineering standards. Sharing of information was one the emphasis put by literature on the mandate for engineering consultants to assist the steel fabrication industry to grow.

Results from the chosen sample indicated that 95% of clients involved in steel fabrication projects feels engineering consultants are important and should be remunerated between 10% and 20% of the total project cost. Engineering consultants were praised for assisting on compliance to standards. Clients indicated that engineering consultants do add value on steel fabrication projects. It is recommended as future research to investigate how satisfied engineering consultants are on steel fabrication projects.

It is recommended to further investigate the engineering consultants' satisfaction to conclude the study on the performance of the whole steel fabrication industry. Engineering consultants also need to indicate how working with clients have been to ensure the required delivery. They could indicate the challenges experience and factors that have contributed to their success. They could also indicate the gaps that will need to be closed to make the steel fabrication industry a highly successful sector. All these opinions could be integrated with those obtained from this report to ensure that a complete view of the industry is obtained.

Keywords: Engineering consultants, steel fabrication projects, compliance to standards

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1. INTRODUCTION

1.1 Background

Engineering consultants are regarded as important stakeholders in engineering, architecture and construction projects (Nazari, Vandadian & Abdirad, 2016). Their role contributes to the cost savings on execution of the projects and they ensure that high quality standard is achieved on the project assigned (Nazari et al., 2016). While some engineering consultants have managed to execute some projects successfully, some projects have failed to deliver to the expectation (Darapu & Darapu, 2014).

There are lot of failure contributions on projects. In case where a project failed, questions that arise include, who managed the project, who was the consulting engineer, was the consulting engineer experienced enough, etc? Engineering consultants are the first to be questioned when there are project failures (Darapu & Darapu, 2014). Stamey (2011) stated that failure of projects is due to poor commitment from planning to sponsorships, which is believed to be the mandate of engineering consultants.

While engineering consultants are mandated to ensure that projects are implemented successfully, they can only achieve that if they are up to date on the standards available to ensure implementation compliance. Standards are developed and monitored by special bodies that government of the countries develops for each engineering discipline.

In South Africa, engineering standards are drafted and enhanced by engineering bodies such as Engineering Council of South Africa (ECSA) and South African Bureau of Standards (SABS). ECSA's primary role is to regulate engineering

profession according to the requirements of the Engineering Act (ECSA, 2023). Engineering consultants should be familiar with all the requirements of the engineering acts and expectations from regulatory body ECSA. SABS is mandated to ensure that products are manufactured to meet all minimum safety and performance requirements, which ensures that benchmarking of South African products with global community. These standards are important for international trade (SABS, 2023).

Consultants need to ensure that such standards are incorporated into engineering projects to build steel structures that are compliant to the latest guidelines from recognised engineering bodies. Muram, Javed and Kanwal (2021) states that compliance is a mandatory requirement for systems or projects that are critical. Hence, ignoring compliance or standards is likely to affect final output of the project, which will result to lawsuits and catastrophic engineering failures.

Alfonso, Cely-Calixto and Penaloza (2022) states that developed countries have noticed a downfall on the productivity curve, which affects performance and quality of engineering and construction industry. This downfall is not directly linked to the work of engineering consultants, however engineering industry relies on experts' knowledge, which are engineering consultants. The impact of non-compliance to the required engineering standards is normally experienced after years of the project implementation. The reputation of the consulting engineering firm is then impacted during this period as clients will use warranties to hold the consulting engineer accountable for any non-compliances experienced.

Engineering consultants are expected to implement working steel fabrication projects, with the required quality and meeting all the standards and safety concerns. Should this expectation not delivered, it is likely that the engineering consultants will be considered incompetent. Engineering consultants are

expected to thoroughly understand clients' needs to be able to implement projects effective and efficiently (Juanzon, 2019).

Public sector is facing more problems than private engineering sector. Contractors servicing the state organization have struggled to get paid on time because they do not submit the required documentation on time. Those that submit documents on time must wait for 30 days after the invoice to get paid, which affects cash flow for contractors (National Treasury, 2023). When there is one error on the document submitted as apart of invoicing in state institutions, documents are left aside and never attended. Procurement will normally wait until there is a query to address it again. 90% of the documents submitted as part of the invoice never include report on the work done with correct signatures. Engineering consultants are required to support contractors with all these issues to achieve good project delivery.

There are normally errors on hours being claimed, incorrect amount being invoiced etc. All these issues delay payments for contractors. Many contractors are left frustrated as payments take long to be processed, which affects their cashflows. Contractors need assistance prior to submission of invoicing to get the process effective. This is the role that engineering consultants should be playing. Many of the government contractors are not as competent as required but do get orders because they meet Supplier Central Database (CSD), Construction Industry Development Board (CIDB) and TAX requirements. This is another factor contributing to poor contractor service delivery as is competency is normally never a criterion to award engineering jobs.

Engineering consultants are supposed to be competent enough to be able to identify contractors with the required capability and those without capability. Competent contractors have now become hesitant to work with government

because of all these inefficiencies. This can be prevented by ensuring that engineering consultant facilitates processes between clients and contractors.

There is a huge need to have a competent person between the state contractors and procurement departments to enhance productivity and efficiency. Procurement departments are normally the drivers of who to award the work with little technical knowledge, which opens the room for corruption. There are measures that have been put in place to fight or eliminate corruption in steel fabrication projects, there is still more work to be done to bring engineering industry to corrupt free case (Owusu, Chan, Degraft, Ameyaw & Robert, 2019). Most engineering departments are led by technicians and handyman with little knowledge on how proper engineering should be executed. This is a gap that engineering consults should close.

Amongst the challenges faced by clients and contractors in steel fabrication projects, the followings were noted:

- Legacy engineering consulting firms owning most of the client's intellectual property (IP), making it difficult for new incumbents to enter the market. These companies respond quickly on enquiries and provide quality feedback, which then forces clients to work with them. Knowledge sharing is the challenge is this scenario.
- Contractors including steel fabricators that are associated with legacy consulting firms and always chosen as preferred suppliers because they have developed good working relationships with clients or consulting firms. This makes it difficult for new incumbents to get business. This speaks to the possible corruption activities as systems doesn't offer far chance foal all contractor that might be interested to the project.
- Contractors working directly with clients are pricing incorrectly and the clients are unable to detect that as they don't have the expertise to know what exactly the services should be costing.

- Contractors are not always honest on their costing, and they remain unchallenged on these issues.
- Contractors are not always for services due to other commitments or complexities of the required service.
- South African legislature and regulations, which sometimes excludes certain groups from participating in the supply chain. This point addresses the requirements of the Broad-based Black Economic Empowerment (BBBEE) Act 53 of 2003 in South Africa.
- Corruption issues facing the sector.

Challenges that engineering managers, maintenance managers, utilities managers and engineers face every day in state own enterprises include the following:

- Competent suppliers hesitating to work with government as regulations including BBBEE excludes some other groups. Most of the groups accommodated by the regulations are not competent on the jobs but qualify to bid for tenders as they meet South African Revenue Service (SARS) and CSD requirements. The execution part of the engineering projects challenges these contractors and expected delivery becomes a challenge.
- Too much interference from by supply chain and procurement on supplier selection, which compromise the quality of the jobs.
- Non-flexible processes to bring competent suppliers on board, projects requiring emergency attention takes time to be attended.
- Lack of the required engineering expertise to drive engineering projects.

In this article, work of the engineering consultants is being reviewed and clients who have worked directly with engineering consultants were given a chance to comment on the value added on their projects. Engineering compliances that

consultants should embrace and implement in steel fabrication projects are highlighted. Afterwards, variables such as value, importance, cost and compliance are used to determine client's satisfaction. Finally, empirical analysis is conducted on a South African engineering society to arrive to the final conclusions.

1.2 Problem Statement

It is not a secret that while there has been successful engineering project on steel fabrication or construction, there are projects that were not delivered to the required expectation. Successful projects have been valued by clients while those that failed have raised concerns from all stakeholders seeking to find causes of failure. There are lot factors that can contribute to project failure including, budget, skill, ignorance, poor, design, incompetent consultants or engineers etc (Taherdoost & Keshavarzsaleh, 2015).

Failed construction projects have compromised development of communities in many ways and have delayed the progress of the societies. Behind many engineering projects on steel fabrication, there are engineering consultants playing a technical role to ensure proper implementation of designs using latest technology and knowledge. Standards are used that have been approved by recognised bodies to ensure compliance. Where engineering projects on steel fabrication or construction have failed, someone needs to be held accountable for damaged occurred.

Projects are considered to have failed if ever time delays were experienced, budget was exceeded and when project was not completed. There are lot of contributing factors to project failure such as procurement of material, labour issues, external factors etc (Puspasari, 2005).

Clients employing engineering consultants on projects are likely to be satisfied if there are no failures and all compliance requirements were met. With projects that have failed, this study seeks to investigate the client's satisfaction on the work conducted by engineering consultants.

The purpose of this study is to explore the role played by engineering consultants in engineering field that are involved in steel fabrication projects. Where clients have been satisfied with the work of consultants, the role will be positive and visa verse when clients are not satisfied.

1.3 Scope Breakdown

This research investigates client's satisfaction on steel projects implemented in South Africa. The focus will be on the following:

- Reasons for project failures or successes.
- Client satisfaction on work done by engineering consultants on steel fabrication projects.
- Interest on future consideration to use engineering consultants.
- Value added by engineering consultants.

It is assumed that all respondents have had a chance to work with engineering consultants and their opinion is based on the experience from interacting with them. The scope of this research is limited to the South African steel fabrication projects that used engineering consultants for design and implementation.

1.4 Research Objectives

This research seeks to investigate client's satisfaction on the work done by engineering consultants during implementation of steel fabrication projects. This leads to the research objectives as follows:

- To understand the client's satisfaction on the work done by engineering consultants for their projects on steel fabrications.

- To understand the importance of complying with engineering standards on steel fabrication projects.
- To understand value added by engineering consultants on steel fabrication projects.

1.5 Research Question

Questions that this research article seeks to answer are as follows:

- Do engineering consultants add value to steel fabrication projects?
- Do clients working with engineering consultants on steel fabrication project satisfied with the work done by engineering consultants?

2 LITERATURE REVIEW

2.1 Introduction

Engineering consulting firms with strong scientific capabilities will need to be supported by technological innovations to remain relevant in this rapidly evolving technological era (Duderstadt, 2007). Wang, Zhang, Fan and Cao (2021) emphasizes on the need for consulting engineering firms to implement smart capabilities for their projects, controlling the whole process of engineering consulting through computer software and implementing digital operation capabilities. Engineering consultants are expected to work together with an engineer, architect, and other specialists to conduct feasibility of the conceptual design to ensure project implementation is civil, structurally and economically sound (Sebastian, 2011).

Engineering consultants and all stakeholders involve in steel fabrication and erection project need to be aware of the existing opportunities and challenges such as reusing the steel and recertification of the steel when a decision to reuse is taken (Tingley & Allwood, 2014). Tingley and Allwood (2014) states that the reusing of steel can have good environmental impact, which is the reason engineering consultants need to consider. Engineering failure stories such as those highlighted by Ryghaug and Sorensen (2009) has put pressure to engineering consultants to ensure that they are avoided for future projects. While on the other hand success stories such as those highlighted by Pantic-Dragisic and Sodelund (2020) has put pressure to engineering consultants to sustain the level of good service provided to clients.

2.2 Applicable Management Theories

Problems in the consulting engineering business are known and require management strategies that are relevant to the current environment.

Management of engineering consulting firm will require an effective strategy to tap to the existing market and explore opportunities.

Management will need to understand clients' needs and desires to ensure the services aligned to the needs is offered. This is applicable to both private and public engineering firms. Engineering consultants need to remember their mandate that they need to enhance efficiency in operation and convenience on huge projects, which required expertise knowledge as they need be the sole institution overlooking all the elements of the projects (Perreault, Cannon & McCarthy, 2009). The idea of having one person responsible for oversight of the project eliminates the possible wastage of money as only one individual is responsible for the overall costing, implementation, and compliance (Perreault et al., 2009).

Competent consultants are required to hold contractors accountable and ensure that all components of the contracts are applied, and contractors comply. For example, if the there is a project that is managed according to the New Engineering Contract 3 (NEC3), contractors need to be held accountable for clauses such as contract data provided by employer, contract data provided by contractor and proforma guarantees (NEC3, 2020). Engineering consulting firm need to be familiar with all different contracts that are used in engineering when executing projects. It is important for engineering consultants to be familiar with contracts such as International Federation of Consulting Engineers (FIDIC) to ensure effective, efficient and non-disputable administration terms and clauses of the contract (Zakaria, Ismail & Yusof, 2013).

Consulting in government institutions requires more than the understanding of the contracts used but the politics involved, all stakeholders, corruption activities, defining and understanding possible problems, analyzing the situation for different departments, getting specific data, interpreting the data, and offering a

solution to the problem (Perreault et al.,2009). Interests of different people and culture in the government institutions is the challenge. The shortage of skills required to execute important tasks is a challenge. Human capacity is not as motivated as it is normally the case in private engineering firms. Normally state institutions are very unionized, which makes decision making a challenge for engineering specialists. Consulting engineering firms need to be able to navigate around these factors to be able to tap into this business and offer value for money for the state funds.

Technology at the state institutions is behind, with most of the equipment old. Operators of the machines are hesitant to adapt to the latest technology as they fear that technology will be taking away their jobs. Engineering consulting firms need to develop a strategy that will be easily accepted by the government employees with more focus on benefits for the employees and proof that technology is not taking jobs away but improving working capabilities and ensuring that work is done better in an efficient way. Luna-Reyes and Gil-Garcia (2014) acknowledges that there is little technological transformation in government institutions and emphasizes that technological transformations will enhance internal processes and strengthen relationships between government and other social and political actors.

2.3 Importance of Engineering Consultants

Engineering consultants are important to ensure that engineering projects assigned are executed successfully. Ng and Chow (2003) states that it is important to undergo an extensive selection process for consultants to determine capability before technical and fee proposals are submitted. Construction projects executed by incompetent consultants exceed budgeted cost and time allocated, quality issues become evidence to most steel structures, there are design errors, lot of reworks and slow decision making. All these issues could be avoided by undergoing a well-crafted pre-qualification process (Nazari, Vandadian, &

Abdirad, 2016). Engineering consultants are capable of accessing required knowledge from different sources to enhance creativity for the given assignment (Kalogerakis, Lüthje & Herstatt, 2010).

Ng and Chow (2003) states that consultants' professional competency, ability to manage projects, resource availability and quality control measures are used together with fees proposals to determine the deserving consultant to be awarded an assignment. Soft skills such as innovative, controllability and commitment are important and relevant skills for engineering consultants thriving to be successful in the competitive industry (Ling, Ofori & Low, 2000)

Law (2009) states that engineering consulting still needs to be professionalised and engineering clients involved on steel structural projects are lacking the ability to comply with professional standards, which makes engineering consulting a continuous need for the industry. A fundamental requirement for engineering projects to be signed by competent and qualified engineers protects clients against lawsuits when catastrophic disasters occur (Law, 2009). Clients can refer all technical enquiries on a project to engineering consultants. Engineering consultants are therefore available to serve this purpose, to ensure that projects meet all standards and quality requirements. In addition, engineering consultants are mandated to satisfy the original desire or need of the project while ensuring that safety of the environment and people is not compromised. Consultants use proven tools to get to the engineered solutions that helps clients to remain relevant in the business space with projects that are sound (Experttoolkit, 2019).

Individual engineers within the engineering consulting firm need to show flexibility, autonomy and ownership to maintain the corporate brand required within the industry (Sheikh, 2011). High discipline in this industry determines the future of the engineering company. Discipline on executing the project implies that meetings set for alignment and discussion are conducted as planned and

communication is clear all the time for stakeholders to follow on the project progress.

Eltahan (2021) states that while there are many procurement processes used top select competent engineering consultant, Qualification-Based-Selection (QBS) has been recognised as the best procurement method for engineering consultant selection.

2.4 Importance of Engineering Contractors

Rahmana, Enduta, Faisola and Paydard (2014) states that collaboration and information sharing is the key to the success of the engineering project. Good communication amongst project members is likely to enhance quality of the project and enhances chances to complete the project on time (Rahmana et al., 2014). Engineering contractors require financing to be in place to be able to deliver on project as per agreed scope (Assaf, Al-Khalil & Al-Hazmi, 1995). According to Riley, Pexton & Drilling (2003), project teams need to be inclusive and integrated to provide well on the demand of open communication and discipline.

Contractors that use value engineering techniques can save cost for the project, project life cycle savings are likely to be realised, value added to the client can be realised and enhanced collaboration with design teams (Ozcan-Deniz & Ramirez, 2021). Ozcan-Deniz et al. (2021) states that technology has improved and materials of construction have improved, which brings an opportunity to design and construct in a more value adding process. Sugiharto, Keith and Sherif (2002) states that contractors seeking to eliminate waste activities should avoid repair work and get work correctly first time, avoid waiting time for equipment, avoid labour and repair and avoid using unreliable equipment.

According to Girmscheid and Hartmann (2001), contractors need to co-operate to realise their ability to be innovative. Co-operation will include usage of new material and new construction principles on projects (Girmscheid et al., 2001). Ofori-Kurugu, Baiden and Badu (2016) states that non-performing contractors will cause projects to be delayed, abandoned or discontinued. The trend of discontinuing projects due to non-performance has been seen in many countries and results to significant loss of investment funding. Key performance indices that have been seen to function well in some countries of Africa within project engineering industry include quality, client satisfaction, cost, time, performance, occupational health and safety, awareness to the environment, productivity and people's effectiveness (Ofori-Kurugu et al., 2016).

Monfared, Mavi and Khakiani (2012) illustrates the criteria used to prioritise payments for contractors to continue with the project's tasks. These criteria include volume of claim, time lapsed form the last payment, amount of last payment and quality of rendered services. It is important to ensure that money is available for contractors to be able to purchase all consumables that are required to complete the project.

2.5 Managing Engineering Consulting Firm

Engineering consulting companies need to manage the knowledge such that they can produce required solutions for the clients in a speedy and qualitative manner (Mezher, Abdul-Malak, Ghosn & Ajam, 2005). Unfortunately, many contractors are unable to take advantage of the market due to the lack of the exploitation of two performance objectives, which are speed and quality.

The key to successful consulting business is the access to information to provide speedy responses. This can be achieved if information is easily accessible and can be retrieved quicker and be used to address client's problems (Mezher et al.,

2005). The marketing of the professional consulting business requires that business promotion be conducted by qualified people with strong ability to articulate engineering knowledge and capable of providing insight on engineering problems (Mustara, Aiz, & Wai, 2008). Mustara et al. (2008) states that while professional consulting firms are mandated to deliver high quality service, they are required to respect the ethical codes, take into consideration client's changing expectations and competition that exists in the sector.

While it is important to acquire technology that is essential and meets customer needs, it is also important to ensure that the technology enhances the performance and contribute to the firm's goals (Haro-Domı´nguez, Arias-Aranda, Llore´ns-Montes, & Moreno, 2007). Haro-Domı´nguez et al. (2007) also emphasizes on technology investing to compete with the market peers as a consulting firm. Aranda, Rata and Duarte (2000) states that innovation in product, process or service of the firm will enhance the market position for the company. Innovation of the companies has become an important requirement to be met, not an option (Aranda et al., 2000).

2.6 Engineering Business Disciplinary Management Theories

Managers are expected to travel around the world to source the latest technology that can be deployed to assist clients on engineering enquiries. Managers should be trained to encourage subordinates and ensure that required support is available and all technological solutions are exploited to the maximum benefit of the client. Managers require a proper plan to dispose old technology once the maximum benefits have been exploited. One option of deploying such technology will be to sell to the peers, which are not technological driven. Krebs and Weber (2021) states that when technology becomes old and worn out, decisions need to be taken if maintenance or repair or dismantle is required.

Management is required to follow trends on latest patent technologies to support the clients on latest development in technology. Patent roadmaps have been found to be capable of providing competitive advantage for some industries (Yu & Zhang, 2019). The use of information technology by companies has been found to be associated with the business performance and continues to add value to stay above competition (Purnama & Subroto, 2016). As stated by Purnama and Subroto (2016), businesses can use technology to process information that is relevant, accurate and timely to make strategic decisions.

2.7 Engineering Standard Compliance

Emmerich, Finkelstein, Antonelli and Armitage (1999) states that compliance to standards is used to develop working documents for the product. These documents could include user requirement specification and process-oriented documents (Emmerich et al., 1999). Complying to the standards is likely to enhance the success of the product, which will imply satisfaction of the client and recognition of the value of the investment. Engineering consulting engineers are expected to drive the compliance to enhance customer satisfaction. Standards are described as reports or documents that have been agreed upon by state authorized bodies, which contains technical specifications and informed rules and guidelines to ensure that developed materials, products, process or services are fit for the desired purpose (Emmerich et al., 1999). This indicates that clients will be satisfied with engineering consultants' job if the compliance requirements are met, and the product is doing the expected function within the spheres of the guidelines.

Industries rely on well recognized standard to certify safety criteria that can be used to prevent system failures that can possibly harm people or environment or animals (Panesar-Walawege, Sabetzadeh & Briand, 2015). Panesar-Walawege et al. (2015) believe that evidence supplied by suppliers to create standards is enough to effectively mitigate the risks, hence the importance of these bodies in the industry. The challenge remains though as all standards are subjected to

different interpretation, which creates a need for those involved in standard formulation interprets to undergo series of formal test that will ensure that interpretation does not vary significantly.

The global advancement in technology has created a need to focus on standards that promote interoperability between systems (McArthur, Davidson, Dimeas, Hatziargyriou, Ponci & Funabashi, 2007). Engineering consultants need to be aware of these developments within the engineering industry. Standards governing applied welding engineering are important to be mastered by consulting engineers as they serve as a basis for steel fabrication (Singh, 2012). Mastering applied engineering welding will imply understanding the processes, codes and all related standards (Singh, 2012).

2.8 Steel Fabrication Projects

Economies of many countries get impacted if the steel fabrication projects are compromised as these projects contributes to about 10% of the country's gross national products (Azimi, Lee, AbouRizk & Alvanchi, 2011). Ensuring that projects meet the targets is an integral part of consulting engineers, this ensures that quality work is delivered and within the set budget (Azimi et al., 2011). Azimi et al. (2011) states that the importance of fabrication projects calls for the need of proper tracking and controlling of all activities within the project. Song (2004) states that accurate measuring and analyzing productivity enhances chances of successful steel fabrication project. This calls for understanding of activities that take place offsite such as fabrication and those happening onsite such as erection (Song, 2004).

2.9 Engineering Consultant's Role

Gura (1984) acknowledges that engineering consultancy on building services needs to be executed by highly educated and trained specialist that are professional engineers. Consulting engineers are required to operate within challenging environments of projects, manage complicated relationships including those of professionals involved, offer the technological expertise of the project at hand and manage all the skills involved within the steel building project (Gura, 1984). Canato and Gingreco (2011) states that consultants have the capability to bring innovation on projects as they have knowledge that originates outside of the organization. Consultants are considered as the sources of latest and relevant information, as the masters of setting the standard required on projects, as spreaders of unknown technological knowledge to make it recognized and usable on projects and integrators of innovative solutions (Canato & Gingreco, 2011).

Rose (2000) emphasis the needs for keeping up with technological changes with the engineering environment if the priority is to remain relevant. The pace at which technology changes requires quick adaptation from engineering consultants and scholars (Rose, 2000). Vogel, Lind and Holm (2019) argue the norm to offer incentives to consultants that have achieved low risk, well proven and well proven technologies on projects. The balance between risk, incentives, innovation and sustainability is required promote smart and sustainable cities (Vogel, Lind & Holm, 2019).

O'Farrel (2012) states that the value that consultants bring on the projects is not more about cost but about the functionality of the product. Value recognition on the project is left to the final evaluation stages and not as part of implementation (O'Farrel, 2012). Project failures seems to be originating from the processes of briefing where information is not as clear as it supposed to be (O'Farrel, 2012). Ibrahim, Aigbedion, Ebekozien, Okbaini, Khan and Amadi (2022) reveals that

engineering consultants agree that technology such as building information modelling, big data, mobile computing and digitalization are the standard technologies used in construction industry, with a lag in developing countries.

2.10 Entrepreneurship Mindset for Steel Fabrication Projects

Antonaci, Dagnino, Otta, Bellotti, Berta, De Gloria, Lavagnino, Romeco, Usart and Mayer (2014) describe entrepreneurship as the capability to convert ideas into actions making use of creativity, innovation, risk taking and proper project planning. Technological capabilities combined with an entrepreneurial mind can be exploited to bring the required innovation that businesses need for sustainability (Antonaci et al., 2014). Whittington, Regner, Angwin, Johnson and Scholes (2020) describe strategic entrepreneurship as an initiative to seek advantages on activities and opportunities with an intention to create value.

Whittington et al. (2020) encourages entrepreneurs to be innovative on identifying and exploiting new and existing ideas. An identified need should be able to satisfy the market to be considered innovative and the originator to be considered entrepreneur (Whittington et al., 2020). This encourages engineering consultants to bring innovative ideas on steel fabrication projects to make projects attractive. Alvaro-Moya, Lopez and Roman (2021) believe that the future of organizations lies on the ability to produce higher value services or goods more efficiently. Steel fabrication industry has no difference, services offered, and fabrication methods are required to be implemented effectively and efficiently to save on cost while maintaining quality. Entrepreneurs are known for commercializing the knowledge to either open new markets or close gaps on the existing market (Alvaro-Moya et al., 2021). Hence, it is critical for consulting engineers to share the latest knowledge with the industry to open new business opportunities.

Social media is the tool that needs to be used strategically by entrepreneurs to create a network with important stakeholders to create knowledge sharing communities (Martin-Rojasa, Garrido-Morenob, García-Morales, 2019). Martin-Rojasa et al. (2019) states that social media can potentially bring knowledge exchange, which then enhances innovation and performance. The ability to be proactive and the willingness to take the risk on ideas that have been innovated is likely to increase financial performance of the business (Martin-Rojasa et al., 2019). Lämmer-Gamp, Meier zu Köcker and Nerger (2014) suggests that market intelligence should be a priority for companies seeking to develop competitive advantage. Companies should priorities information collection for the industry and analyze it with an intention to maximize findings. Cluster organizations can be a useful to provide this information (Lämmer-Gamp et al., 2014). Consulting firms on steel fabrication projects are encouraged to collect industry data and maximize on the findings.

De Maeyera and Bonne (2015) recommends that new business models should be created such that they capture the value of innovation. Entrepreneurs are encouraged to combine social power and economic power by creating a network of resources within the communities (De Maeyera and Bonne, 2015). Evidence-based information is favoured by entrepreneurs compared to scientific methods as it aligns with sharing economy (De Maeyera and Bonne, 2015). Engineering consultants are challenged to shift their mindset from scientific methods to evidence-based knowledge.

2.11 Engineering Consulting Business

Intellectual capital is the most important asset of the engineering consulting firm that will determine its operational capability (Huang & Hsueh, 2007). Huang and Hsueh (2007) highlight that innovation, sharing and utilization of knowledge can enhance engineering consulting firm’s competitiveness and performance. Wong (2012) highlighted the importance of clear and coordinated government policies

to allow engineering firms to compete effectively in the market. Exports initiatives on the knowledge acquired recognition of the engineer's board are amongst the important points required by the engineering firm (Wong, 2012). Sustainable corporate governance assist meets the demands of the business, efficiency in operations and opens possibility to practice internationally (Chen, Chou, Wang, Wei & Yang, 2021).

2.12 Engineering Contractor Business

Contractors are known for their huge impact in enhancing socio-economy of many countries and play vital role for skills development (Mahamid, 2012). Mahamid (2012) describes factors such as shortage of infrastructure, consultants' problems and contractors' incompetency as amongst the top causes of contractor failures in the market. Contractors seeking to compete and survive in the market need to adapt their operation to the business environment, with technology and globalization threatening the contractor industry (Kawesittisankhun & Pongpeng, 2019). Kusuma, Soemardi, Pribadi and Yuliar (2019) encourages contractors to master technology as part of improving technological capabilities by using technology learning.

All available forms of funding should be exploited for the engineering consulting firm. These finding methodologies include bootstrapping finance, micro-financing, debt financing etc.

2.12 Literature Review Summary

The key focus of the engineering consulting business is regarded as management of latest technology that can be used to solve engineering problems. Management will be required to be technology driven and innovative

compared to the peers. Managers is encouraged to source the knowledge globally to be able to create big data base that can be shared with the industry. Exhibitions on engineering are encouraged to check what available technologies that can be used to assist clients with engineering problems. Inability of clients to comply with engineering standards has made consulting business a continuous need for the industry. Consulting engineers are expected to be masters of all contract clauses that are binding contractors and clients.

Engineering consulting firms need to master knowledge management to effectively compete in the market, while contractors need to improve their capabilities through technological learning.

Contractors will need to professionally collaborate with consultants and clients to be able to recognize optimum effectiveness of the assignment. Engineering consulting in government organizations require an understanding of politics and possible corruption activities to assist the client to realize value of money. Creativity, innovation and technology play an important role on developing a sustainable engineering consulting business. Funding of businesses include acquiring funds from bootstrapping finance, micro-financing, debt financing etc.

Entrepreneurial mindset and innovation are encouraged for engineering consulting firms working on steel fabrication projects to erect projects that are attractive and satisfying to the design requirements.

3 METHODOLOGY

A methodology designed to meet the three set objectives was designed. This research adopted survey methodology to collect data on client satisfaction on the usage of engineering consultants. The sample that was targeted was the individuals, engineers, clients and specialists that have directly worked with engineering consultsnts in South Africa. All responses obtained were modelled using Statistical Package for Social Sciences (SPSS). First step was to identify all stakeholders that are directly affected by the work of consulting engineers. Figure 1 shows the conceptual framework of all involved stakeholders to bring the required output that is valued by the end user.

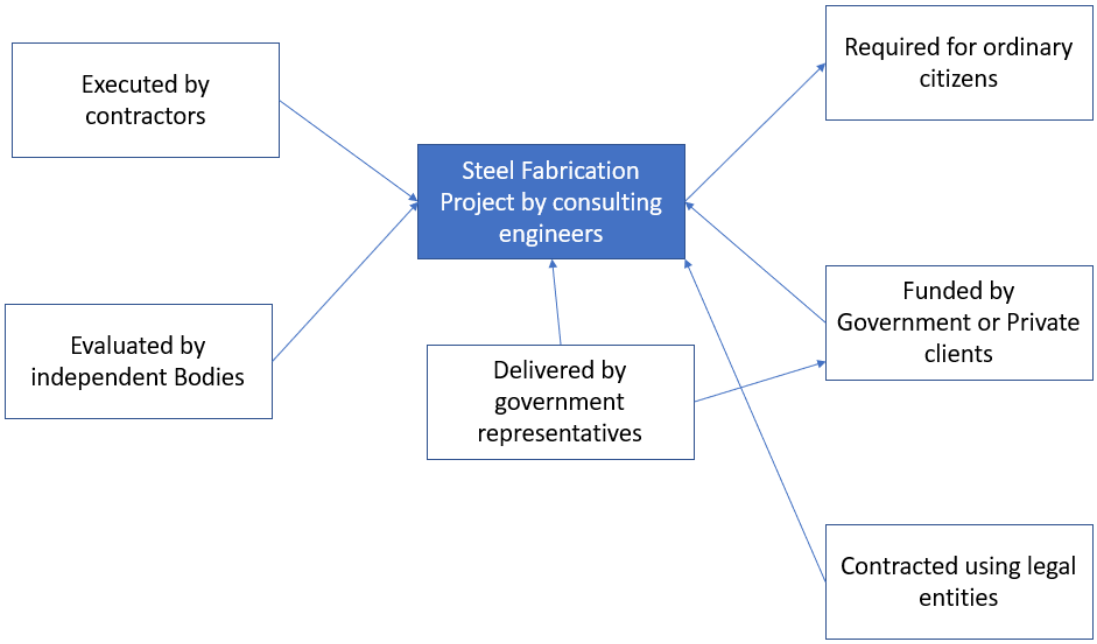


Figure 1: Parties interested on a steel fabrication and erection project.

End users are normally ordinary citizens that will be making uses of the project that is being implemented. They don't have the required knowledge on how projects should be implemented but will provide judgement on whether the project is meeting their need or not. This stakeholder is useful to determine if the need was satisfied or not based on the output of the project. Alternatively, it could be a firm requiring steel fabrication project either to expand or satisfy a specific business requirement. The same logic applies, since the firm is the end user,

satisfaction on the output can be provided by responsible stakeholders. Contractors are used to conduct erection and steel fabrication to ensure realization of the need at hand. They are in a better position to indicate if the project was successfully delivered or not. They can give an idea on the assistance and guidance provided by consulting engineers duding steel project implementation. Depending on the type and extent of the project, there could be independent bodies such as delegates from Engineering Council of South Africa (ECSA) that might seek to verify and approve work done.

In some cases, department of labour might be interested on auditing site safety practices to check compliance to the occupational health and safety standards. If it is a state project, there will be state representative interested on the progress of the project. There are also legal issues that need to be dealt with for huge projects, which involved legal experts. All the above stakeholders will have an opinion on the work done by consultants and whether they are satisfies or not.

Question that would normally arise from these stakeholders would be justifications if the money invested was used as required. Quality assurers would be interested to know if all engineering standards were accommodated to bring the project to existence. The possibility of ignoring certain standards is likely to introduce technical failures to the project, which will compromise project's intention, hence ruin reputation for involve consultants and contractor. During contractual agreements, there will be discussion on how much consultants needs to be remunerated.

Literature review on the work done by engineering consultants provided an opportunity to identify areas that are important to effectively assist on steel fabrication projects. Both qualitative and quantitative research methodologies were adopted in order to fully understand the role of engineering consultants in ensuring good delivery of steel fabrication projects and complying with all

engineering standard that ensures minimal risk to the society. Primary data were collected from 200 engineering practitioners that are currently active in engineering industry in a form of surveys (APPENDIX A shows the survey instrument used). These practitioners included steel contractors, associates representing state and private organization on projects involving steel fabrication and construction and engineers involved in steel and fabrication projects.

Data collection has been done using 45 surveys that were hand given to contractors who attended site briefings for the projects on steel erection, fabrication and construction around Johannesburg. These briefings were located in Johannesburg and attended by all South African contractors who had interest, there was no limit on who to attend. These briefing were held between 01 December 2022 and 31 January 2023. This was regarded as appropriate time to collect data as most suppliers are planning on projects for the new financial year. 20 Responses were obtained from the 45 issued surveys, this is 44% response rate for the briefings. 155 Surveys were issued using email attached with an anonymous link.

Figure 2 shows the snapshot from Qualtrics with all responses. Qualtrics software was used to create the survey instrument. As seen in Figure 3, 21 responses were obtained, which is 14% response rate. Surveys using emails were sent between 09 January 2023 and 19 January 2023, which is a period where most engineering practitioners are back at work and preparing for the new year. During this period, engineering practitioners are not experiencing work pressure, which increases the probability of getting time to respond on surveys.

Surveys via email were sent to many practitioners that are involved in engineering steel fabrication projects, including European practitioners that emails were available during the time of distributing surveys. These emails were meant to cover big engineering community active on steel fabrication projects.

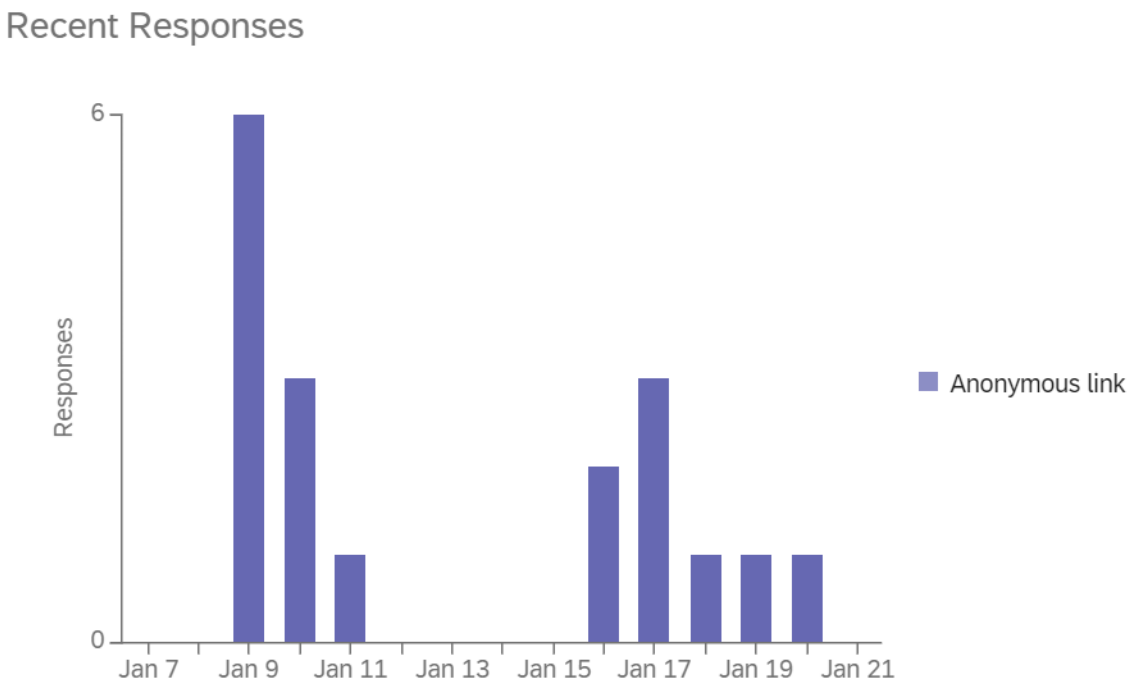


Figure 2: Date of data collection using emails and anonymous link

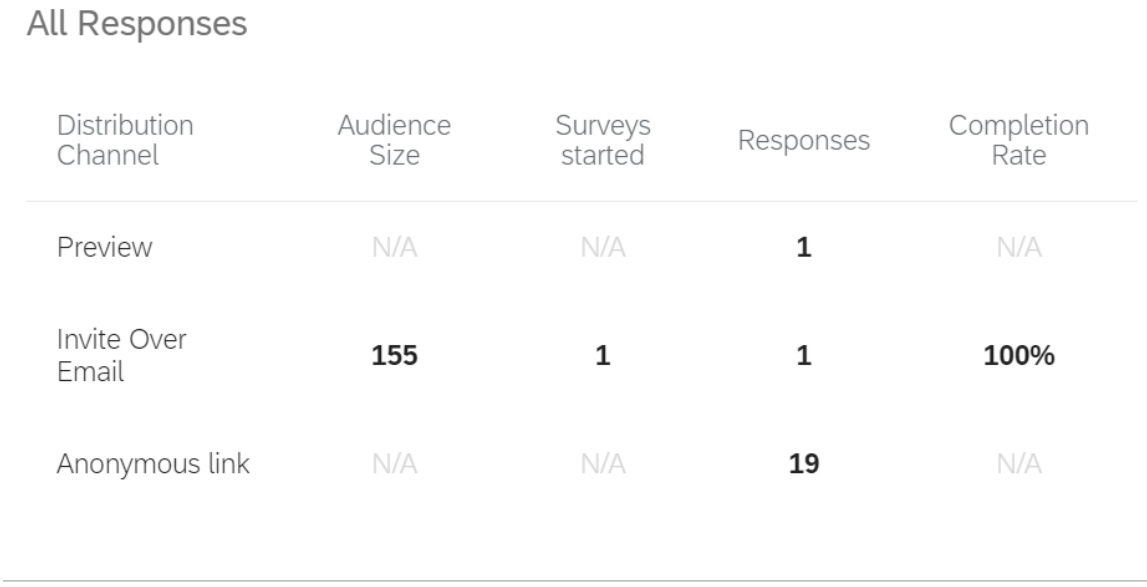


Figure 3: Response rate using anonymous link

A total of 41 surveys was received from steel fabrication engineering community out of the 200 surveys sent, which is 21% response rate. As shown in Appendix A, the structured survey questions have helped to answer the research question as tabulated earlier, which are:

- Do engineering consultants play significant role in ensuring compliance to standards on steel fabrication projects?
- Have engineering consultants complied with engineering standards to bring to life robust steel fabrication projects?
- Do engineering consultants add value to steel fabrication projects?

This research used purposeful sampling, which requires input from major participants. The major participants included engineers in steel fabrication projects, contractors erecting steel, clients owning steel fabrication projects, government officials involved in infrastructure building and representatives from private organizations that work on steel fabrication projects.

The sample took 6 minutes on average to complete. A pilot study was conducted where two participants were sent the survey. Feedback on the analysis of the pilot study was to revisit some of the question to eliminate ambiguity and then structure them according to the variables of target.

All participants were informed about the purpose of the study and the ethics requirements governing data collection. Participants had to agree on the ethics agreements first before continuing with the survey. All data was collected anonymously as the research doesn’t not require participants identifications. Qualtrics tool was used to collect data using anonymous link while that collected during the briefings, surveys were independently issued and collected by the owner of the briefing.

3.1 Site Briefing Data Contributions

Site briefings for steel fabrication projects in Johannesburg attracted contractors from all over South Africa, which gave an opportunity to extract well informed data from contractors that work directly with consultants. It was noted that not all contractors were interested in answering the data. It is possible that crucial information was lost from the contractors that opted not participate.

3.2 Engineering Steel Fabrication Industry Data Contributions

Only 14% responded on the survey. The data collected was treated carefully to accommodate the limitations that might have prevented the 86% participants that opted not to respond on the survey.

4 RESULTS AND ANALYSIS

This section analyses results from the hand delivered surveys i.e. surveys from briefings and those that were obtained using anonymous links on Qualtrics. Emails with the anonymous link were sent to targeted group of practitioners in steel fabrication industry.

4.1 Briefings Results Analysis

Four respondents indicated that engineering consultants are being used at most three times per week, while five indicated once after three months. One responded indicated that there is never a case where engineering consultants are used, this contractor might not be relevant for this case and his opinions will need to be eliminated from the data as part of data cleaning. All respondents indicated that the role played by engineering consultants is important. 53% Respondents indicated that engineering consultants understands standards required to bring success to steel fabrication projects, 37% was not sure if standards are being understood and 5% disagreed that standards are being understood.

Survey showed that 95% of the respondents believe that engineering consultants are important on the projects involving steel fabrication and steel erection. This also was confirmed by 95% respondents agreeing that engineering projects require the services of the engineering consultants. There was no responded that indicated that engineering consultsnts are important for cost savings, but many respondents mentioned compliance and proper management of project. On average, respondents feel engineering consultants should be paid 23% of the total cost of the project. The qualifications that consultants should at least engineering degree according to the respondents, with doctorate being the best qualification to have.

There is inconsistent noticed on the importance of the role played by engineering consultants as later 100% of respondents believed consultants are playing significant role. The 5% percent that earlier disagreed engineering are important, later stated that engineering consultants play important role. About 80% respondents believe engineering consultants should have 80% knowledge on the subject of interest to be able to add the required value on the required output. About 14% of the respondents believed that enough knowledge is enough to get the required delivery from engineering consultants. About 90% of the respondents have worked directly with engineering consultants, which brings confidence that they are giving firsthand information on the input by engineering consults.

All respondents believe engineering consultants are knowledgeable on the task to be delivered. About 85% agree that by paying consultants to assist on projects, they have realized the value of money, which implies the usage of constants did add value. Ten percent believe there is no real value by using consultants. All respondents indicated a positive probability to use engineering consultants in future. Majority of respondents indicated that they choose to use consultants on projects exceeding R2 million, while significant respondents indicated that R500 000 and R2 000 000, they see a need to use consultants. There is also a significant number that believed that even small projects deserve the attention from engineering consultants.

Majority of respondents believed that the usage of engineering consultants results to the cost savings on projects, which is the value realized by clients. About 94% of respondents believe that engineering consultants have delivered high quality of work, which could be due to compliance to set standards.

4.2 Main Results of Online Survey

As seen in APPENDIX B and Table 1, there were some missing information from respondents, which will need to be cleaned. For example, respondent 1 only answered first two questions of the survey, which is not adding value for the required variables. Hence, responses from this respondent will have to be removed. Respondent 20 indicated that service of engineering consultants is used once after three months, but he sees no importance of using it. This respondent did not indicate what exactly he uses consultants for and if they need to be experts or not. No indication of preferred qualifications from this respondent. The missing information makes it difficult to trust responses from this responded, removal of his responses was opted.

Table 1: Respondents from online survey

Respondent	Frequency	Importance	Standards	Role	Payment	Qualifications	Knowledge	Involvement	Value	Cost
1	1	Yes								
2	0,04	Yes	No	Compliance	3%	Degree	Expert	Yes	Yes/No	2M+
3	0,08	Yes	Yes	Cost	60%	Masters	Knowledgeable	Yes	Yes	500K
4	0,75	Yes	Yes	Compliance	10%	Degree	Expert	No/Yes	Yes	2M+
5	0,25	Yes	Yes	Cost	60%	Masters	Expert	No	No/Yes	500K
6	0,25	Yes	Yes	Manage	15%	Masters	Expert	Yes	Yes	2M+
7	0,08	Yes	Yes	Compliance	20%	Degree	Expert	Yes	Yes	2M+
8	0	Yes	No		20%	Degree	Expert	No	Yes	
9	0,02	Yes	Yes	Compliance	10%	Doctorate	Expert	Yes	Yes	500K
10	0,04	Yes	*Yes*	Compliance	10%	Masters	Expert	Yes	Yes	2M+
11	0,08	Yes	*Yes*	Compliance	5%	Degree	Expert	Yes	Yes	2M+
12	0,75	Yes	*Yes*	Compliance	20%	Degree	Knowledgeable	Yes	Yes	500K
13	3	Yes	*Yes*	Compliance	40%	Masters	Knowledgeable	Yes	Yes	500K
14	1	Yes	*Yes*	Compliance	20%	Masters	Expert	Yes	Yes	0
15	0,02	Yes	*Yes*	Compliance	8%	Degree	Expert	Yes	Yes	0
16	3	Yes	*Yes*	Manage	20%	Masters	Expert	Yes	Yes	2M+
17	0,08	Yes	*Yes*	Compliance	20%	Doctorate	Expert	Yes	Yes	2M+
18	1	Yes	*Yes*	Manage	15%	Doctorate	Expert	Yes	Yes	2M+
19	3	Yes	*Yes*	Manage	18%	Doctorate	Expert	Yes	Yes	500K
21	0,04	Yes	*Yes*	Compliance	15%	Doctorate	Expert	Yes	Yes	2M+
22	3	Yes			62%	Doctorate	Expert	No	Yes	500K

Respondent 22 did not indicate if engineering consultants are important or not. However, he indicated that he will be using engineering consultants in the future. Using engineering consultants in the future gives probability that they are important, which is the main cause why his response on the importance was modified to be “Yes”. Responded 8 indicated that he never uses engineering consultants and is not involved in any steel fabrication or erection projects. Responses from this responded are then questionable as he has no experience on the actual work done by engineering consultants. A decision was taken to remove his responses from the survey. APPENDIX C shows clean data for the online survey responses.

Important variables for this study were frequency of using engineering consultants, importance of service from engineering consultants, Compliance to standard by engineering consultants, feedback on the role engineering consultants seems to be playing in the industry, indication of remuneration, qualifications of engineering consultants, involvement of respondents on projects, feedback on weather value is added by engineering consultants and the cost where consultants are brought for service. As can be seen in Table 2 below, majority of the respondents indicated that consultants are being used at about 156 times per year, while the other equal number of respondents indicated that engineering consultants are used four times a year. Results in Table 1 indicates that engineering consultants are being used on steel fabrication projects.

Table 2: Number of using consultants per year

Frequency					
Consultations in a week		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	1	4.8	5.0	5.0
	.02	2	9.5	10.0	15.0
	.04	3	14.3	15.0	30.0
	.08 (4)*	4	19.0	20.0	50.0
	.25	2	9.5	10.0	60.0
	.75	2	9.5	10.0	70.0
	1.00	2	9.5	10.0	80.0
	3.00 (156)*	4	19.0	20.0	100.0
	Total	20	95.2	100.0	
Missing	System	1	4.8		
Total		21	100.0		

*usage of consultants converted to yearly

Table 3: Role played by engineering consultants

Role					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		3	14.3	14.3	14.3
	Compliance	12	57.1	57.1	71.4
	Cost	2	9.5	9.5	81.0
	Manage	4	19.0	19.0	100.0
	Total	21	100.0	100.0	

As tabulated above in Table 3, majority of the clients working with engineering consultants indicated that they get assisted more to comply with the standards used for steel fabrication projects.

Table 4: Qualification recognised for consulting in engineering

Qualifications					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		1	4.8	4.8	4.8
	Degree	7	33.3	33.3	38.1
	Doctorate	6	28.6	28.6	66.7
	Masters	7	33.3	33.3	100.0
	Total	21	100.0	100.0	

Results in Table 4 indicated that individuals with university degrees or above are adequate to practice as engineering consultants in steel fabrication projects.

Table 5: Knowledge expectation from engineering consultants

Knowledge					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		1	4.8	4.8	4.8
	Expert	17	81.0	81.0	85.7
	Knowledgeable	3	14.3	14.3	100.0
	Total	21	100.0	100.0	

Table 4 shows that expert knowledge is the expectation from the clients on the steel fabrication projects. Clients are bound to believe experts on the suggestion to deliver and comply with standards according to the results shown. Table 5 indicates that majority of respondents prefer to use engineering consultants on projects from R2 million and above. Table 6 indicates the importance rating for engineering consultants by the steel fabrication industry while Table 7 indicates the client's satisfaction on assistance to comply with the standards.

Table 5: Projects costs comparisons

Cost					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		2	9.5	9.5	9.5
	0	2	9.5	9.5	19.0
	2M+	10	47.6	47.6	66.7
	500K	7	33.3	33.3	100.0
	Total	21	100.0	100.0	

Table 6: Importance of engineering consultants

Importance					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		1	4.8	4.8	4.8
	Yes	20	95.2	95.2	100.0
	Total	21	100.0	100.0	

Table 7: Compliance to standards rating

Standards					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		2	9.5	9.5	9.5
	No	2	9.5	9.5	19.0
	Yes	17	81.0	81.0	100.0
	Total	21	100.0	100.0	

Consultants needs to be paid for the work done. Table 8 indicates opinions from clients on the amount that shat should be paid to clients in terms of the total percentage of the project cost. Table 9 indicates the amount of responses that was contributed by clients that are involved on the steel fabrication problems, which gives confidence on the responses obtained.

Table 8: Payment amount for engineering consultants

Payment					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3.00%	1	4.8	5.0	5.0
	5.00%	1	4.8	5.0	10.0
	8.00%	1	4.8	5.0	15.0
	10.00%	3	14.3	15.0	30.0
	15.00%	3	14.3	15.0	45.0
	18.00%	1	4.8	5.0	50.0
	20.00%	6	28.6	30.0	80.0
	40.00%	1	4.8	5.0	85.0
	60.00%	2	9.5	10.0	95.0
	62.00%	1	4.8	5.0	100.0
	Total	20	95.2	100.0	
Missing	System	1	4.8		
Total		21	100.0		

Table 9: Responses obtained from clients involved in steel fabrication projects

Involvement					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		1	4.8	4.8	4.8
	No	3	14.3	14.3	19.0
	No/Yes	1	4.8	4.8	23.8
	Yes	16	76.2	76.2	100.0
	Total	21	100.0	100.0	

Table 10 below shows the quantity of clients that indicated that they realise value from the work done by engineering consultants on steel fabrication and erection projects. Additional tables are found in APPENDIX D.

Table 10: Amount of value added by engineering consultants on projects

Value					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		1	4.8	4.8	4.8
	No/Yes	1	4.8	4.8	9.5
	Yes	18	85.7	85.7	95.2
	Yes/No	1	4.8	4.8	100.0
	Total	21	100.0	100.0	

4.3 Combination Results

The percentages from both samples collected in the briefings and those collected online using anonymous links were aligned. Results from briefings indicated that engineering consultants in steel fabrication projects are important, which was the case with the online results. Both groups indicated that engineering consultants add value during implementation of steel fabrication projects. They also indicated that assistance on the compliance to standards is the highly valued factor from engineering consultants. Ten of the project cost was the minimum recommendation from both groups and 20% recommended to be the maximum. This is higher than the 6% minimum recommended by ECSA.

As mentioned above, the biggest role that both groups indicated that is played by engineering consultants is to assist with compliance requirements. Majority of that respondents from both groups were involved on steel fabrication projects and working directly with engineering consultants. Both groups indicated bright future for engineering consultants working on steel fabrication projects.

5 DISCUSSIONS

As shown in Table 3, 57% of the people involved in the industry believe that the biggest role that engineering consults is playing in steel fabrication and erection projects is to ensure compliance to engineering standards. This implies that engineering consultants need to work together with bodies that set standards to contribute on the content to be published for standards. Engineering consultants are likely to assist on the feasibility to meet the compliance requirements. They are practical as they are physically involved on the project, they know what works and what doesn't.

Compliance requirements will only be met when they are practical. Engineering consultants can contribute to assist the engineering industry with practical solutions to improve steel fabrications and erection projects. Hojem and Legesen (2011) states that the need to comply with legal requirements is more of a business opportunity for consulting engineers rather than professional ethics. Legal standards are viewed as the right instrument to trigger business for consulting engineers Hojem & Legesen, 2011).

A portion of the respondents believe that engineering consultants should play a project management role as their primary function. Management of projects includes ensuring that steel fabrication and erection project is completed on time, within budget and met all the quality expectations. As much as the results revealed management factor as secondary, it is likely to enhance success of the project when it is done parallel with the primary task, which is compliance. Wen, Qian and An (2017) states that engineering consultants are a critical catalyst to project management for project to be successful but stated that if incorrectly used, negative results can be obtained.

Cost was not regarded as critical on steel fabrication projects by the respondents, which investors will argue. Cost management was rated third as the role to be played by engineering consultants. This indicates that respondents believe that regardless of how much it takes to comply, engineering consultants should never compromise compliance. This brings the ethics to the context. Compliance normally ensures that ethical concerns on designs and environment are considered, which implies additional costs. According to the results, balancing cost and compliance was not prominent. Business executives will always try to find a balance, however respondents feel that money should be invested to ensure compliance. Xiaoyu (2020) disagrees with the outcome of the research and states that cost management plays the core role to the success of the project from start to finish of the project.

Table 4 rated qualifications as valued by engineering industry. It is apparent that the industry feels that consultants should have engineering qualification to be able to add value to the industry. Results do not give a clear indication on which qualification level is rated high by the engineering industry. A third of the population believes that a university degree is enough to equip engineering consultants with the required knowledge to practise as consultants. Another third believes that masters should be regarded as entry level to be able to practice as a consultant. While the last third believes that doctorate degree will provide you with specialised knowledge on the subject, which then gives you rare knowledge to practice as a consultant.

It is interesting to note that more than 90% of the respondents believes that at least a qualification is required to practice as an engineering consultant. This brings a challenge for engineering professionals to confront industry expectations and assist with knowledge sharing to enhance the quality on steel fabrication projects. While almost all respondents believed that a qualification of some kind is required, 81% of them indicated that engineering consultants need to be experts on steel fabrication projects to be able to add value to the industry. In

general, experts are highly educated, and hold doctorate degrees. Engineering consultants with university degrees need to accept the industry expectations that they need to enhance their skills and qualification to the level regarded as experts, which is likely to be doctorate qualification. Eltahan (2021) states that project management qualifications are used as the basis to select consulting engineers for the task. The qualifications give capability for consulting engineers to deliver on the task (Eltahan, 2021).

It is general knowledge to easily believe experts advise that that of the ordinary person. The same logic within the steel fabrication projects applies as industry is indicated that expert knowledge is valued more than 80%. Experts are likely to enforce compliance with the understanding of financial risk and what is likely to be robust to sustain the steel fabrication project. It is not clear whether the knowledge of interest is gained from formal education or through practical experience on steel fabrication projects. Ertmer, Stepich, York, Stickman, Wu, Zurek, and Goktas (2008) states that experts are quick to solve problems in engineering than novies, which them makes sense to employ experts for steel fabrication project to be effective. This theory suggest that expertise is achieved through experience and not via formal education. Formal education enhances expertise (Ertmer et al., 2008).

Majority of the industry involves engineering consultants on projects that are valued above R2 million. Projects in this range are classified as medium to high steel projects. According to Construction Industry Development Board (CIDB), grading on contractors should be Civil Engineering (i.e. CE2) or General Building 2 (i.e. GB2) and above, which indicates the seriousness of these projects. Of course, not a single client will forsake millions of rands, hence it is better to be assisted with expert knowledge on these projects. A reasonable portion of the industry believes that even projects valued around R500 000 required consultant’s attention. This ensures that risk of failure is minimised as all compliance issues on stell fabrication projects are addresses by experts.

Heralova (2017) states that the cost of the project should consider the project life cycle, which will include construction, operation, maintenance and disposal. Engineering consultsnts with their expertise knowledge can then assist to determine the cost of the project life cycle (Heralova, 2017)

There is 10% of the engineering industry that uses consultants regardless of the value of the project. Although reasons behind using engineering consultants all the time were not investigated, it is likely that this 10% does not have required engineering capabilities to execute steel fabrication projects. It is also possible that there are other priorities from the business that ensures that engineers are not deployed on projects, rather outsourcing the whole steel fabrication projects. The problem with outsourcing the whole activities on steel fabrication projects is the loss of experience for in-house capability that is required to sustain business future. Advantages are that the business never worries about execution during implementation stage as consultants take all decisions on behalf of the client. While Somjai (2017) agrees that advantages for outsourcing include obtaining expertise knowledge and allowing clients to focus on core business processes, Somjai (2017) also worries about exposing confidential data to wrong partners for the business.

As seen in Table 6, 95% of the engineering population involved in steel fabrication projects believes that engineering consultants are important. Consultants are believed to be regarded as important due to the service they have offered to the industry and reputation that they have created to the clients. The level of education and information sharing is likely to be the other reason that the clients have opted to regard engineering consultants as important. The choice to consider engineering consultants as important is enhanced by the results in Table 10 where 85% of the sample involved in steel fabrication projects stated that presence of engineering consultants in steel fabrication projects add value. Normally, value will be considered as added when the client objectives and long-term goals were achieved by the delivery of the consultants. Those clients that

used engineering consultants for all the service only realise value added when they take over the complete working project and implement. The clients that were part of the project will realise value from information shared on the project and all compliance issued complied with to ensure that environmental impacts are minimised.

The value proposition from engineering consults is indeed accepted and appreciated by the community involved on steel fabrication projects. It would be interesting to further investigate how engineering consultants feel about their clients and where improvements can be implemented. Table 7 indicates that 81% of the population involved in steel fabrication projects agrees that engineering consultants are indeed helpful to assist with compliance requirements on projects. This helps the clients to minimise the risk of paying fines to the statutory bodies due to non-compliances in operation. Hence, consultants feel that engineering consultants on steel fabrication projects are adding value. There is 10% minority that has had bad experience on the service of consultants, which challenges those consultants in the industry to promote their work such that the 10% does not tarnish their work valued by many.

There was a huge discrepancy on the percentage that engineering consultants should be remunerated for the assignment given. About 29% of the sample in the steel fabrication projects believes that 20% of the total project cost should be the remuneration benchmark for engineering consultant's service. This 20% cost is the maximum recommendation from ECSA (2023). The 10% recommended payment for consultants by other portion is still within the acceptable payments, depending on the size of the project (ECSA, 2023). This indicates that clients are prepared to pay more than the minimum recommended value for the valued service from engineering consultants involved in steel fabrication and erection projects. Only 14% of the population agreed with ECSA on the 10% payment for the consultancy. These values didn't not consider the contingency on the project but considered the actual cost.

It is interesting to note that 76% of the sample is involved steel fabrication projects managed by the engineering consultants. This percentage gives confidence on the feedback obtain from the sample and represents the population of interest meaningfully. Referring from last paragraph, it is transparent that clients owning steel fabrication projects value the input from engineering consultsnts. 86% Indicated that engineering consultant's contribution on steel fabrication projects is valued.

The first research objective was to investigate if clients are satisfied with the work of engineering consultants on steel fabrication projects. It is clear from the results that clients are satisfied with this input as 85% of the population indicated that value is recognised when working with engineering consultsnts. Satisfaction was also stressed by 95% indication of importance of engineering consultants as indicated by the industry. Most of the clients indicated that engineering consultants are important to ensure compliance to engineering standards.

The second objective was verified by the indication that 81% of the respondents felt that engineering consultants are assisting on compliance to the set standards and that they feel it is important to comply. This affirmation provides a challenge to the engineering consulting industry to maintain the good service level and thrive to deliver above expectations. The 87% indication of value recognition affirms the third objective that engineering consultsnts are valued by clients when they assist to comply with the standards. Complying to the standards assist clients to avoid possible lawsuits and loss of revenues.

The results are aligned with the logic reasoning from the community as engineering consultants are highly rated academics of the society. Industry would rely to them in terms of knowledge sharing and ensuring that projects are implemented correctly. Results obtained from this research are indeed aligned to the engineering community expectations.

6 CONCLUSIONS

The research conducted revealed that clients involved in steel fabrication projects are satisfied with the work done by engineering consultants to ensure all compliance to standards are met during fabrication and erection of steel projects. This specific industry feels it important to have engineering consultants for these projects to drive requirements on compliance to standards. Complying with compliance assist clients on statutory obligations and helps eliminate the possibility of getting fined by statutory bodies. The steel fabrication and erection industry feels that engineering consultants are adding value to the projects and should be paid on between 10% and 20% of the total cost of the project.

Steel fabrication and erection industry believes that at least university degree qualification is required to be able to interpret standards for the assignments to be delivered. Experts with doctorate degrees are highly appreciated by the industry and their information sharing is valued. Engineering consultants were praised for assisting with compliance to standards. Many clients working on steel fabrication projects prefers using engineering consultants on projects above R2 million.

Research revealed that many clients involved in steel fabrication projects are satisfied with the work done by engineering consultants. This was the first objective of the research. This also indicates that engineering consultants have a bright future in steel fabrication projects as their work is highly valued by the industry. Many clients indicated that they use engineering consultants to assist with compliance requirements. This is the indication that clients working on steel fabrication projects consider compliance as an important factor in steel fabrication projects. This was the second objective, which also showed that engineering consultants have the bright future in steel fabrication projects.

Industry clients in steel fabrication projects revealed that engineering consultants are adding value to the projects. Engineering consultants are challenged to maintain the standard in order to keep clients happy with the service. The expectations are high from the industry, hence engineering consultants need to keep up with the global changes, new technology and new innovations.

Research questions were answered as results revealed that clients working with steel fabrication consultants are satisfied and believe that consultants are adding value.

6. RECOMMENDATIONS FOR FUTURE WORK

The focus for this research was more on how clients involved in steel fabrication projects feel about engineering consultants. Engineering consultants could be given a chance as well to indicate their satisfaction on the work they do for clients on steel fabrication projects. Input from engineering consultants will assist this research to fully conclude on the activities occurring in steel and fabrication projects. More variables can be introduced to determine industry trends and gaps that can be explored to improve steel fabrication and erection projects. Bodies governing the standards on steel fabrication projects can be involved to add their input on the variables that can assist the industry to improve.

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APPENDIX A: SURVEY INSTRUMENT

CSAT Intro

Participant Information Sheet,

Dear Sir / Madam,

My name is Buhlebezwe Mthokozisi Khumalo and I am currently doing MBA at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating client satisfaction on using engineering consultants. My supervisor is Dr Peterson Owusu Junior. The aim of this research project is to discover **THE ROLE OF CONSULTANTS IN ENSURING COMPLIANCE TO ENGINEERING STANDARDS IN STEEL FABRICATION PROJECTS.**

As part of this project, I would like to invite you to take part in answering the survey below. This survey will take around 7-10 minutes. This data collected will be deleted after 2 years.

There will be no personal costs to you if you participate in this project. You will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. Participation will be completely confidential and anonymous as I will not be asking for your name or any identifying information, and the information you give to me will be held securely and not disclosed to anyone else. I will be using a pseudonym (false name) to represent your participation in my final research report.

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online through the university library website. If you wish to receive a summary of this report, I will be happy to send it to you (optional). The data collected from this research project will be stored at Wits Business School and will be kept permanently. With your permission the data collected from this research project may be used by other researchers in an anonymized format. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the Prof Antony Stacey, chair of the WBS Research Ethics and Academic Misconduct Committee at Anthony.stacey@wits.ac.za .

Yours sincerely,
Buhlebezwe Khumalo

Researcher:
Buhlebezwe Khumalo, 0410666W@students.wits.ac.za, 067429 2183

Supervisor:
Dr Peterson Owusu Junior, bethpeniel@gmail.com

○ Yes, I agree to the information above

How often do you use engineering consultants for your engineering services?

- ○ 2-3 times per week
- ○ Once per week
- ○ 2-3 times per month
- ○ Once per month
- ○ Once every 2-3 months
- ○ Once every 6 Months
- ○ Once per year
- ○ Never

Is the role played by engineering consultants on steel fabrication projects important?

- ○ Yes
- ○ No
- ○ I do not know

Do you believe that engineering consultants understand all compliance standards required on steel fabrication projects?

- ○ Yes
- ○ No
- ○ Maybe
- ○ I don't know

Purchase experience Satisfaction and Importance

Do you think engineering consultants are important in steel fabrication projects?

- ○ Yes
- ○ No
- ○ I do not know

Do you think engineering projects need engineering consultants?

- ○ Yes
- ○ No
- ○ I do not know

What role does engineering consultants play in steel fabrication projects? Promote engineering compliance, manage projects, save costs etc.?

Usage experience Satisfaction and Importance

How much of the total project cost should engineering consultants be paid (choices below are percentages)?

	0	10	20	30	40	50	60	70	80	90	100
Pay engineering consultants XX%											

What qualifications should engineering consultants have?

- ☐ Doctorate
- ☐ Masters
- ☐ Degree
- ☐ Any qualification
- ☐ No qualification

Is the role played by engineering consultants on steel fabrication projects important?

- ○ Yes
- ○ No

After purchase service (warranty, repair, customer service, etc.) Satisfaction and Importance

How much knowledge should engineering consultants have on the steel fabrication projects?

- ○ Expert
- ○ Enough knowledge to complete tasks
- ○ No knowledge
- ○ I do not know

Are you involved on engineering steel fabrication projects?

- ○ Yes
- ○ No
- ○ Sometimes

Overall Satisfaction, Customer Service, Future

Do you work with engineering consultants?

- ○ Yes
- ○ No

Do you think engineering consultants are knowledgeable?

Yes	No
○	○

Do you realize the value of money paid for engineering consultants?

- ○ Yes
- ○ No
- ○ I do not know

Will you be hiring engineering consultant's services in future?

- ○ Yes
- ○ Maybe
- ○ No

From what cost of the project do you involve engineering consultants?

- ○ Never involve them
- ○ 0 - R500 000
- ○ R500 000 - R2 000 000
- ○ All the time
- ○ Above R2 000 000

Do you think engineering consultants are important?

- ○ Yes
- ○ No
- ○ Not sure

Do you think using engineering consultants on steel fabrication projects contributes to client cost savings?

- ○ Yes
- ○ I do not know
- ○ No

Do you think engineering consultants deliver high quality service on steel fabrication projects?

- ○ Yes
- ○ Not sure
- ○ No

Powered by Qualtrics

APPENDIX B: ORIGINAL DATA

Respondent	Frequency	Importance	Standards	Role	Payment	Qualifications	Knowledge	Involvement	Value	Cost
1	1	Yes								
2	0,04	Yes	No	Compliance	3%	Degree	Expert	Yes	Yes/No	2M+
3	0,08	Yes	Yes	Cost	60%	Masters	Knowledgeable	Yes	Yes	500K
4	0,75	Yes	Yes	Compliance	10%	Degree	Expert	No/Yes	Yes	2M+
5	0,25	Yes	Yes	Cost	60%	Masters	Expert	No	No/Yes	500K
6	0,25	Yes	Yes	Manage	15%	Masters	Expert	Yes	Yes	2M+
7	0,08	Yes	Yes	Compliance	20%	Degree	Expert	Yes	Yes	2M+
8	0	Yes	No		20%	Degree	Expert	No	Yes	
9	0,02	Yes	Yes	Compliance	10%	Doctorate	Expert	Yes	Yes	500K
10	0,04	Yes	*Yes*	Compliance	10%	Masters	Expert	Yes	Yes	2M+
11	0,08	Yes	*Yes*	Compliance	5%	Degree	Expert	Yes	Yes	2M+
12	0,75	Yes	*Yes*	Compliance	20%	Degree	Knowledgeable	Yes	Yes	500K
13	3	Yes	*Yes*	Compliance	40%	Masters	Knowledgeable	Yes	Yes	500K
14	1	Yes	*Yes*	Compliance	20%	Masters	Expert	Yes	Yes	0
15	0,02	Yes	*Yes*	Compliance	8%	Degree	Expert	Yes	Yes	0
16	3	Yes	*Yes*	Manage	20%	Masters	Expert	Yes	Yes	2M+
17	0,08	Yes	*Yes*	Compliance	20%	Doctorate	Expert	Yes	Yes	2M+
18	1	Yes	*Yes*	Manage	15%	Doctorate	Expert	Yes	Yes	2M+
19	3	Yes	*Yes*	Manage	18%	Doctorate	Expert	Yes	Yes	500K
21	0,04	Yes	*Yes*	Compliance	15%	Doctorate	Expert	Yes	Yes	2M+
22	3	Yes			62%	Doctorate	Expert	No	Yes	500K

APPENDIX C: CLEANED DATA FROM QUALTRICS

Respondent	Frequency	Importance	Standards	Role	Payment	Qualifications	Knowledge	Involvement	Value	Cost
2	0,04	Yes	No	Compliance	3%	Degree	Expert	Yes	Yes/No	2M+
3	0,08	Yes	Yes	Cost	60%	Masters	Knowledgeable	Yes	Yes	500K
4	0,75	Yes	Yes	Compliance	10%	Degree	Expert	No/Yes	Yes	2M+
5	0,25	Yes	Yes	Cost	60%	Masters	Expert	No	No/Yes	500K
6	0,25	Yes	Yes	Manage	15%	Masters	Expert	Yes	Yes	2M+
7	0,08	Yes	Yes	Compliance	20%	Degree	Expert	Yes	Yes	2M+
9	0,02	Yes	Yes	Compliance	10%	Doctorate	Expert	Yes	Yes	500K
10	0,04	Yes	*Yes*	Compliance	10%	Masters	Expert	Yes	Yes	2M+
11	0,08	Yes	*Yes*	Compliance	5%	Degree	Expert	Yes	Yes	2M+
12	0,75	Yes	*Yes*	Compliance	20%	Degree	Knowledgeable	Yes	Yes	500K
13	3	Yes	*Yes*	Compliance	40%	Masters	Knowledgeable	Yes	Yes	500K
14	1	Yes	*Yes*	Compliance	20%	Masters	Expert	Yes	Yes	0
15	0,02	Yes	*Yes*	Compliance	8%	Degree	Expert	Yes	Yes	0
16	3	Yes	*Yes*	Manage	20%	Masters	Expert	Yes	Yes	2M+
17	0,08	Yes	*Yes*	Compliance	20%	Doctorate	Expert	Yes	Yes	2M+
18	1	Yes	*Yes*	Manage	15%	Doctorate	Expert	Yes	Yes	2M+
19	3	Yes	*Yes*	Manage	18%	Doctorate	Expert	Yes	Yes	500K
20	0.08	No			32%			Yes	No	
21	0,04	Yes	*Yes*	Compliance	15%	Doctorate	Expert	Yes	Yes	2M+
22	3	Yes			62%	Doctorate	Expert	No	Yes	500K

APPENDIX D: ADDITIONAL SPSS TABLES

Table 11: Descriptive analysis

Descriptive Statistics						
	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Frequency	20	.00	3.00	.8240	1.16306	1.353
Payment	20	3.00%	62.00%	22.5500%	18.16728%	330.050
Valid N (listwise)	20					

Table 12: Descriptive Statistics

Descriptive Statistics						
		Statistic	Bootstrap[a]			
			Bias	Std. Error	95% Confidence Interval	
					Lower	Upper
Frequency	Mean	.8240	-.0017	.2531	.3571	1.3485
	Std. Deviation	1.16306	-.04794	.19745	.68642	1.39864
	N	20	0	0	20	20
Payment	Mean	22.5500%	-0.1044%	3.8136%	15.6500%	30.3987%
	Std. Deviation	18.16728%	-0.82478%	3.41744%	8.72272%	22.53623%
	N	20	0	0	20	20

a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Table 13: Correlations

Correlations					
Pearson Correlation		Frequency		Frequency	1.000
				Payment	.335
		Payment		Frequency	.335
				Payment	1.000
Sig. (1-tailed)		Frequency		Frequency	.
				Payment	.074
		Payment		Frequency	.074
				Payment	.
N		Frequency		Frequency	20
				Payment	20
		Payment		Frequency	20
				Payment	20
Bootstrap for Pearson Correlation[a]	Bias	Frequency		Frequency	.000
				Payment	-.005
		Payment		Frequency	-.005
				Payment	.000
	Std. Error	Frequency		Frequency	.000
				Payment	.231
		Payment		Frequency	.231
				Payment	.000
	95% Confidence Interval	Lower	Frequency	Frequency	1.000
				Payment	-.099
			Payment	Frequency	-.099
				Payment	1.000
		Upper	Frequency	Frequency	1.000
				Payment	.769
			Payment	Frequency	.769
				Payment	1.000
a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples					

Table 14: Variables Removed

Variables Entered/Removed[a]			
Model	Variables Entered	Variables Removed	Method
1	Payment[b]	.	Enter
a. Dependent Variable: Frequency			
b. All requested variables entered.			

Table 15: Model Summary

Model Summary[b]										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.335[a]	.112	.063	1.12587	.112	2.276	1	18	.149	2.076
a. Predictors: (Constant), Payment										
b. Dependent Variable: Frequency										

Table 16: Bootstrap for Model Summary

Bootstrap for Model Summary					
Model	Durbin-Watson	Bootstrap[a]			
		Bias	Std. Error	95% Confidence Interval	
				Lower	Upper
1	2.076	-.792	.430	.523	2.197
a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples					

Table 17: ANOVA

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.885	1	2.885	2.276	.149[b]
	Residual	22.817	18	1.268		
	Total	25.702	19			
a. Dependent Variable: Frequency						
b. Predictors: (Constant), Payment						

Table 18: Coefficients

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.340	.408		.835	.415	-.516	1.197
	Payment	.021	.014	.335	1.509	.149	-.008	.051
a. Dependent Variable: Frequency								

Table 19: Bootstrap for Coefficients

Bootstrap for Coefficients							
Model		B	Bootstrap[a]				
			Bias	Std. Error	Sig. (2-tailed)	95% Confidence Interval	
						Lower	Upper
1	(Constant)	.340	-.020	.369	.343	-.484	1.031
	Payment	.021	.002	.020	.262	-.005	.074
a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples							

Table 20: Residual Statistics

Residuals Statistics[a]						
		Statistic	Bootstrap[b]			
			Bias	Std. Error	95% Confidence Interval	
					Lower	Upper
Predicted Value	Minimum	.4047				
	Maximum	1.6702				
	Mean	.8240	-.0017	.2531	.3571	1.3485
	Std. Deviation	.38967	.00273	.25617	.01479	.90464
	N	20	0	0	20	20
Residual	Minimum	-1.54727				
	Maximum	2.27359				
	Mean	.00000	.00000	.00000	.00000	.00000
	Std. Deviation	1.09585	-.08470	.20133	.54616	1.34145
	N	20	0	0	20	20
Std. Predicted Value	Minimum	-1.076				
	Maximum	2.171				
	Mean	.000	.000	.000	.000	.000
	Std. Deviation	1.000	.000	.000	1.000	1.000
	N	20	0	0	20	20
Std. Residual	Minimum	-1.374				
	Maximum	2.019				
	Mean	.000	.000	.000	.000	.000
	Std. Deviation	.973	.000	.000	.973	.973
	N	20	0	0	20	20

a. Dependent Variable: Frequency

b. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Table 21: Correlations

Correlations				
		Frequency	Cost2	Payment
Frequency	Pearson Correlation	1	-.336	.335
	Sig. (2-tailed)		.160	.149
	Sum of Squares and Cross-products	25.702	-8.426	134.506
	Covariance	1.353	-.468	7.079
	N	20	19	20
Cost2	Pearson Correlation	-.336	1	-.476*
	Sig. (2-tailed)	.160		.040
	Sum of Squares and Cross-products	-8.426	25.237	-189.158
	Covariance	-.468	1.402	-10.509
	N	19	19	19
Payment	Pearson Correlation	.335	-.476*	1
	Sig. (2-tailed)	.149	.040	
	Sum of Squares and Cross-products	134.506	-189.158	6270.950
	Covariance	7.079	-10.509	330.050
	N	20	19	20
*. Correlation is significant at the 0.05 level (2-tailed).				