The roles of engineering consultants in the southern African power sector

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ABSTRACT

Historically, a main theme behind the roles of engineering consultants has been the constant adaptation to the progressive requirements of their clients. It therefore stands that the roles of engineering consultants require constant re-evaluation to ensure that they are up to date with clients' needs today. This study, based in the context of southern African power systems, aims to identify and evaluate the key roles required from engineering consultants. An online and paper survey was presented to clients, of engineering consultants, to evaluate the extent to which they have; currently, and intend to use, the services of engineering consultants in key roles. The study statistically compared the current and intended uses of 22 roles using the technique of depended t-tests and non-parametric related tests. These tests revealed statistically significant positive differences between the current and intended uses of consultants in all roles, each of which indicated greater intended future use. The study found that while the traditional roles, like specialist ability and accountability, were not being threatened, roles which were considered new to the field were growing at a higher rate. In addition, while clients indicated higher overall use of consultants in future, public sector clients revealed higher use than private clients. In summary, advisory and technical roles remain key for clients in the short term, however, staff issues such as retention and training are growing concerns for clients which need to be addressed by consultants. The trend reveals engineering consultants requiring the establishment of a more holistic, customer oriented approach to serving client needs.

DECLARATION

I, Dinesh Pithambaram Moodley, declare that this research report 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 University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Dinesh Pithambaram Moodley

Signed at ……

On the …….. day of …… 2013

DEDICATION

This report is dedicated to my wife, Nirvana and daughter, Neha, who are my inspiration to wake up every morning. I love you both and thank you for motivating me to complete what I have started.

ACKNOWLEDGEMENTS

I would like to acknowledge the following people for their assistance in making this report possible:

- My wife, Nirvana, without whom my life would be a mess;
- My supervisor, Prof. Greg Lee, for his assistance and his advice;
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1.1 Purpose of the study

The purpose of this research is to evaluate the role of engineering consultants in the context of the southern African power sector. This study attempts to clarify the service offerings, thereby establishing a renewed look at role requirements of engineering consultants.

1.2 Context of the study

Today's engineering consultants are purveyors of expert skills, specialist knowledge, latest best practice and project management expertise, all in an attempt to reduce the overall costs and increase the aggregate factor productivity (Roberts, 2004). The origins of the practice are rooted in a basic needs base, stemming from gaps in the industry. Service offerings of consultants often attest to these by groups of often disconnected services like environmental impact assessment and power systems design.

The purpose of engineering consultants is best understood when drawn down to its modest beginnings. Roberts (2004) speaks about the industrialisation era, where the roots of engineering consulting lie. They started in the machine manufacturing process, which defined the heart of the era, and went on to define three roles of the then, engineering consultant. The first being the purveyor of new ideas for faster, more efficient processes and production, this research and development role involved the adaptation of the plant to suit the individual customer needs. Segregation of this role from the mainstream plant activities created better use and a centred focus on the knowledge base for these engineering consultants. The second role required the adaptation of plant interface with largely complex plants. This interfacing required specific and often expert skills in the plant structures and its intricacies, and as before, separation of this department from the rest of the manufacturing process made sense for the

same reasons. Lastly, multi-disciplinary functions allowed the engineering consultant to manage the full plant investment via all the complex and multi-faceted interfaces. While, the roles of consultants have stayed the same, they have also changed; the mechanical function of design and project development has been augmented with the growing need to engage in a bigger picture outlook in line with the growing needs of their clients.

The theoretical needs for engineering consultants' uses are based on two central characteristics, which differentiate them from their closest alternative: a client's own engineering function. The first revolves around the complexity and project scale, which drives the use of external consultants. The regularity of diverse projects drives the knowledge about the 'best practice' in all aspects of the project. Second, the lumpiness and irregularity of investment projects, defy the need for the client's own engineering overheads that are infrequently required (Wilmot, 1995). These 'economies of scale' and 'economies of knowledge' are the fundamental drives for early adoption of engineering consultants by clients.

Taking this to the African context, this outlook is driven by a number of factors. These factors all contribute to the changing landscape in which the engineering consultant finds him/herself.

Aside from the theoretical reasons for engineering consultants, developing countries like those in southern Africa, have spawned an additional need for engineering consultants, due to the lack of technological know-how and ailing engineering capacity. Engineers per capita indices (Figure 1), often used as a key index for the country's ability to grow, paint a bleak picture of the capacity of South Africa, as well as neighbouring countries (Toit, 2008). Figure 2 details engineers in southern Africa's 2005 indices, with South Africa having almost six times less registered engineers than its nearest emerging market rival, Malaysia. Data from other sources has not changed the picture. The CESA (2011) survey for 2011 places the average percentage of firms experiencing difficulties in acquiring more engineers at 80 per cent. Engineering consultants in this environment are sought to fill the gaps and introduce significant efficiency to the client's process; thereby streamlining the engineering function, creating

economies of scale savings for clients (Roberts, 2004; Waring, 1993). A second need from the African context has been the role of the engineering consultant in the form of an autonomous entity, vetting the flow of funds from the financiers to the suppliers. Overall, the engineering consultant's roles have been keenly adapted and expanded over the years to the constantly changing environment they work in; from the research and development (R&D) engineering functions of the industrialised era to substituting the owner's role in the developing nations of today.

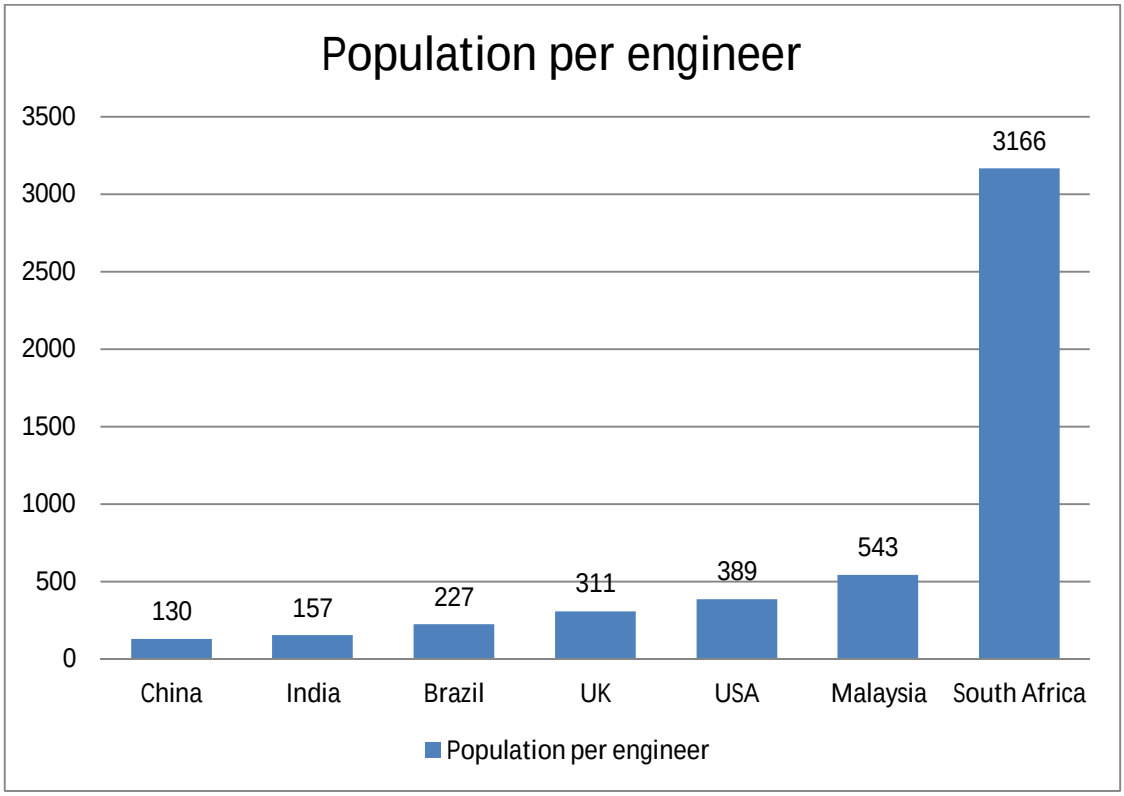


Figure 1: Registered engineer to population ratios

(Toit, 2008)

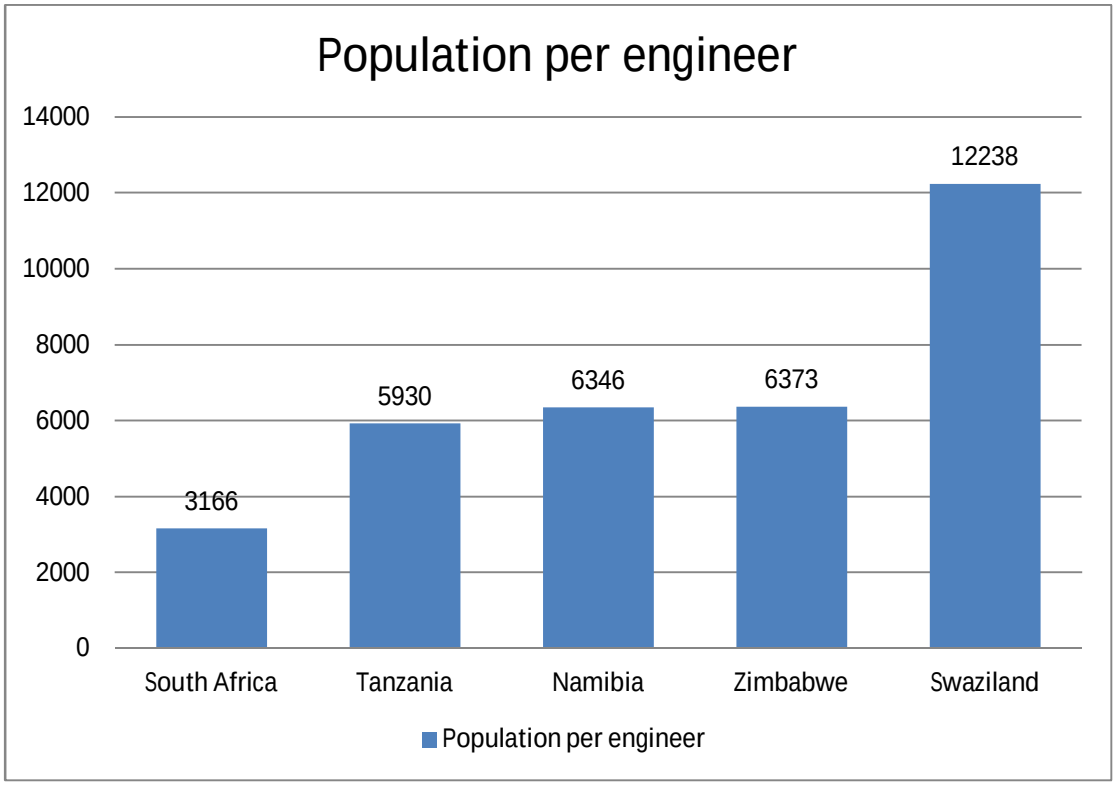


Figure 2: Registered engineers in African states

(Toit, 2008)

Thus far, the uses and needs of engineers have been explored on a micro level, and clearly the proliferation of engineering roles has been driven by needs and filling the gaps. The question around the importance of filling these gaps remain, especially so for the power sector, the next section attempts to explore this relative importance.

On the macro level, the importance of the power system to developing nations is undeniable; it speaks directly to the economic and social prosperity of the country. Without capacity for growth and satisfactory reliability, a power system can restrict the capacity for businesses to grow and thereby stunt the progress of the country (Development Bank, 2008). Further evidence, from studies, show that in developing countries, the growth in the demand for electricity is very closely correlated with that of its GDP growth (Abaidoo, 2011). The power sector in southern Africa is no different in this respect; high GDP growth combined with low per capita electrification rates sets the regional sector up for high power system

growth (Wall, 2010). Figure 3, details the GDP growth rates, population counts and electrification rates for most countries in the Sub-Sahara. A power system expansion aided by growth, and growth aided by an expanding power system, is at the basis of a self-sustaining economy (Abaidoo, 2011).

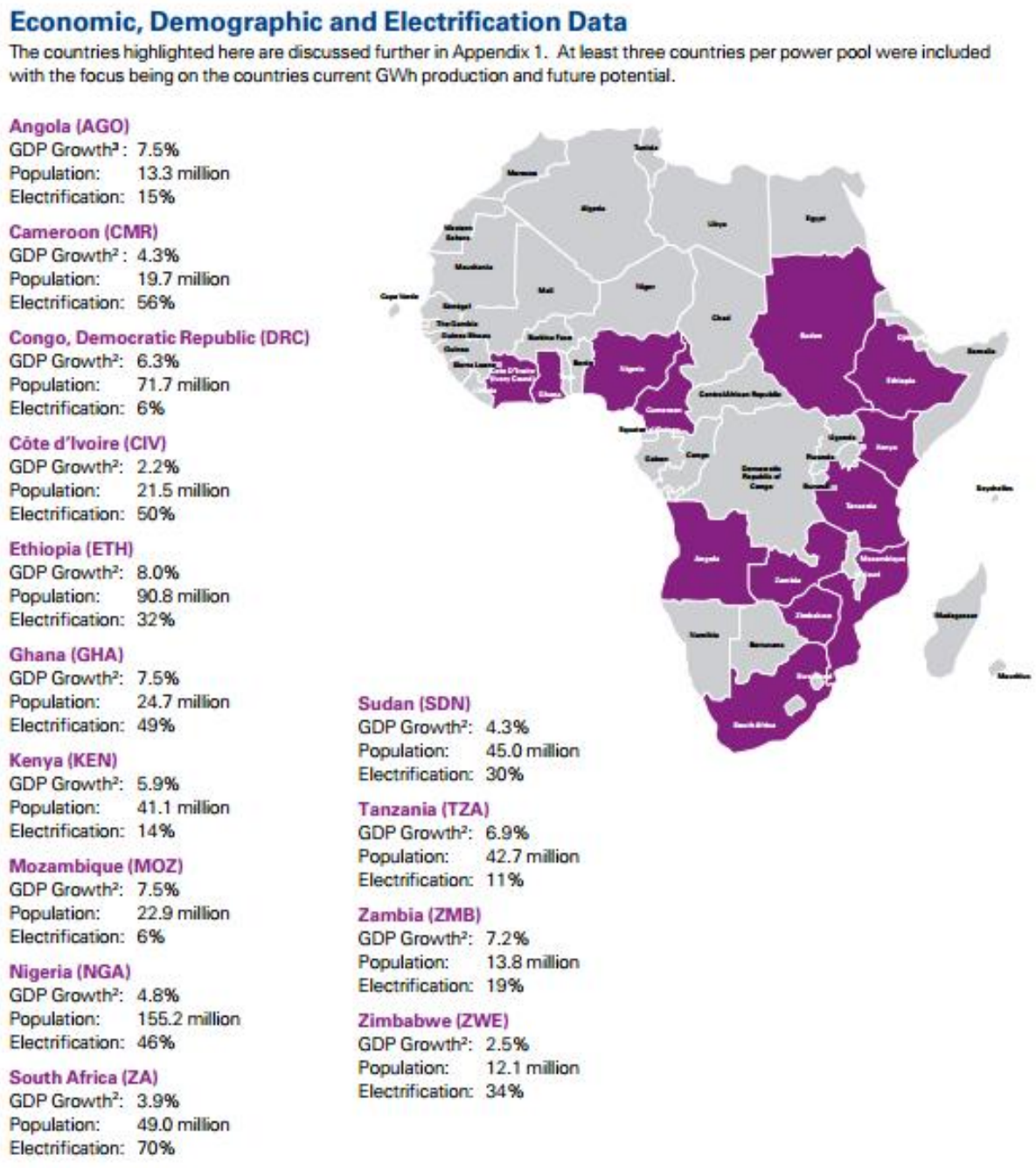


Figure 3: African GDP growth, population and electrification figures

(Infrastructure & Projects Group Africa Team, 2011)

The relative stability of these economies and a growing middle class in the region has spun off interest from international investors and suppliers alike ("Where to invest in Africa," 2011). The proliferation of many multinationals within the southern African region is testament to this, all being driven by the constant hunger for revenue growth, many finding their ever-diminishing First World markets failing to satisfy their ambitious shareholders. Prevalence of globalisation is apparent in the amount of privatisation of the government institutions (typically including the energy sector), and lowering of the tariff barriers (especially so for other partner developing countries like SADAC), which lead to higher trade growth outlooks ("World Economic Outlook," 2012). Complexities brought about by globalisation have augmented the role of the engineering consultant and solidified the notion of a technical partner on the rapid growth in the industry.

There appears to be a growing disconnect within the power sector around the offering of the engineering consultant (O'Farrell, 2010). This is demonstrated by the slow increase in income for the electrical sector, relative to other sectors (Figure 4), whereupon growth in the electrical sector only tops two per cent compared to chemical and structural both of which are in excess of six per cent. In the context of the growing needs of the engineering consultant, this presents a clear disconnect, especially, when contrasted against the general confidence of clients of the sector (Figure 5) of whom almost 90 per cent were found to be satisfied with the service rendered. In spite of the augmentation of uses and needs for engineering consultants, and the growing macro-economic needs, the growth in consulting revenues from this sector remains low.

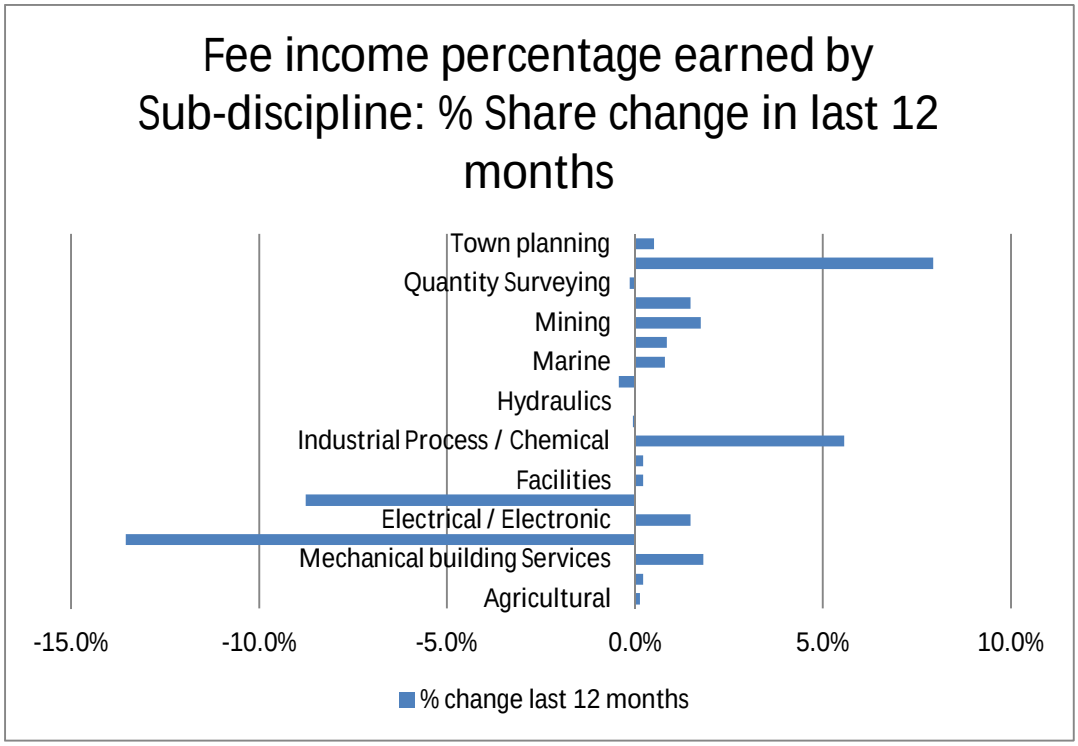


Figure 4: Biannual CESA Fee income earned

(CESA, 2011)

Admittedly, the reasons for the slow growth in the electrical consulting sector could be due to other factors, which are not sighted here, however, peeling back the layers is the only way to get to the core of this issue. In addressing the next layer, the roles of engineering consultants need to be considered. The potential for mismatch of the requirements of engineering consulting roles and clients' needs are certain to spell lower revenue for the sector, and while this is not the motivation for this report, a regular realignment between the consultant and the client is critical to the relevance of the profession which is seen to be constantly adapting.

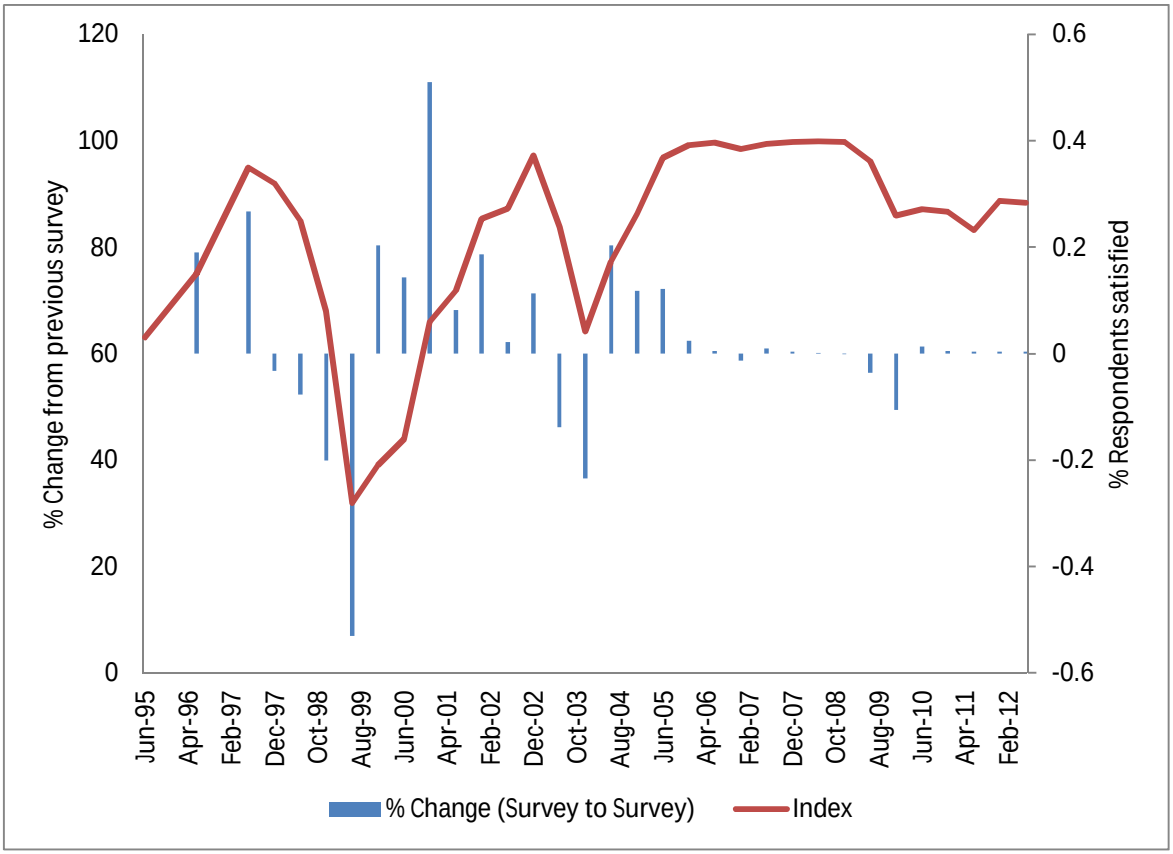


Figure 5: Biannual CESA client satisfaction survey

(CESA, 2011)

1.3 Problem statement

1.3.1 Main problem

Analyse engineering consulting roles, and contrast these against the clients' requirements of engineering consultants within the southern African power systems sector.

1.3.2 Sub-problems

The first sub-problem is to determine the pool of roles, both existing and new, which clients' require from engineering consultants.

The second sub-problem is to identify and evaluate roles, which clients intend to use more in the future than currently.

1.4 Significance of the study

Studies abound on both the assessment of the value that clients attribute to the service levels of engineering consultants (Samson & Parker, 1994; Stone, 2006) and the importance of knowledge resources on the firms (Baark, 2001), however, little can be found on what work engineering consultants should be producing (FIDIC & UNEP, 2002). Significant changes within all facets of the industry environment has led to growing pressures placed on engineering consultants as evident by declining margins (CESA, 2011) and the growing nature of clients linking up directly with suppliers (O'Farrell, 2010). Research suggests that issues like innovative design (Bhojaram, 2012), changing client types (CESA, 2011), changing procurement methods (Williams, 2012), and greater emphasis on incorporating sustainability and social aspects into design (Wall, 2010), have not been adequately addressed by existing engineering consulting roles (FIDIC & UNEP, 2002). This presents a significant threat to the local industry which, in 2011 accounted for R 17 billion in revenue and employed more than 22 000 people (CESA, 2010).

The study will give the engineering consultants a perspective on the needs attached to the roles of engineering consulting. This will allow the engineering consultant firms to formulate strategies for the roles they wish to pursue.

1.5 Delimitations of the study

The study will only deal with the transmission and distribution clients in the southern African power sector.

The engineering consultants considered are regarded as purely external consultants, the clients' own internal consultants are not considered in this research.

1.6 Definition of terms

- *Power system*: Components used for the generation, transfer and distribution of power to households, factories and offices (Grainger, 1994);
- *Engineering Consultancy:* A set of methods and organizational structures which allow relevant scientific, technical and economic knowledge to be gathered and converted into designs and instructions for the construction of specific (in our case industrial) projects (Roberts, 2004).

1.7 Assumptions

The following assumptions have been made regarding the study:

- Global issues affecting engineering, as a whole, are seen to affect the work of engineering consultants;
- The total number of respondents will be sufficient to gain adequate data, unless otherwise stated;
- Project information will be conveyed honestly and truthfully by the respondents. False data will have a severely detrimental effect on the study's results; and
- The respondent sample will reflect the general experiences of the office within which they work. Non-representative views could skew the results of the study and reduce its validity, for this reason a methodology of diverse sampling, where possible, was used to aid in this challenge.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The literature gathered was found to follow similar themes, which were not specific to this topic. Limited works in both engineering consulting and African centric engineering trends allowed for limited views to be explored. A similar study by Nippa and Petzold's (2002) on the roles of management consultants established similar findings from their literature review. They recognised that

> "… while experience-based explanations lack consistency, completeness and theoretical underpinnings, the selective use of distinct theories highlights only certain aspects of the problem, while excluding other aspects and explanations" (Nippa & Petzold, 2002, p. 218).

This research recognises this same shortcoming and attempts to address it by means of supplementary qualitative interviews, which are sought to create these experience-based explanations.

This literature review begins with the way in which customers perceive value from engineering consultants, it then progresses to detail the use of roles within the context of this study, after which it details each of the main trends in the client's and consultants landscape.

2.1.1 The concept of value

It is critical to define the value that is derived from the services of engineering consultants because this speaks to the purpose of the engineering consultant in their existing context. In this way, the roles can be sought which further extend their value.

Value is defined as what clients receive in benefits, such as compiled reports, versus what they are asked to sacrifice in terms of money, time and effort

(Lapierre, Filiatrault, & Chebat, 1999). A quantitative study done by Lapierre et al. (1999), indicated that, in the professional services context, value, which is determined by both quality and total price, affects satisfaction, moreover the intent to buy (or rebuy) services is a function of satisfaction. Thus, it stands; consultants should pursue a value orientation. This could address any one or all of the levers in the definition of value (time, money, effort), such as getting customers to spend less time in the process, consultants operating more independently, or using consultant staff to do the work of the client's staff.

This relevance of value in engineering consultants is reaffirmed by O'Farrell (2010) who suggests that in their roles as consulting engineers, customers are increasingly dissatisfied due to the lack of customer service and value for money; and by Duderstadt (2008) who contends that engineering needs to move up the value chain to higher order activities. This can be achieved by including attributes of radical innovation, immune (self-healing) design, applications testing to enable market optimization and even financial planning to create further value.

2.1.2 The definition of roles

The definition of roles in the context of this study, allows for a clear delimitation of the study. This is considered due to; the widespread definition of a role, the ambiguity around its definition in differing contexts, and the need to scope the study to a defined set of paradigms.

Nippa and Petzold (2002) define the task of a consultant as defining and presenting solutions while supporting the management position, they go further to detail that by looking at the essentials of this task, it is possible to define the roles and functions which encompass this position. They contend that there is no distinction between roles, tasks and functions of consultants, and that the tasks and functions are aspects for which consultants are hired rather than filling a certain role. Roles are regarded as enabling features to the objectives of consultants, so for example, while the role of a teacher is to teach, one function of a teacher would be to test his/her pupils. This distinction is important for the

remainder of this report because it focuses the study and allows the resulting analysis to be more succinct.

When attempting to formalise the definition of roles in the context of this report, it was found suitable to relate this to marketing principals, namely, the 'three levels' of a product theory (Kotler & Keller, 2009). The authors define three categories of benefits: core, actual and augmented offerings, each of which are customer centric views of the product. This research attempts to combine this categorisation with the definition of roles, functions and tasks to allow the establishment of a definition that will aid in the research findings. Figure 6 defines the correspondence between the definitions and categorisations.

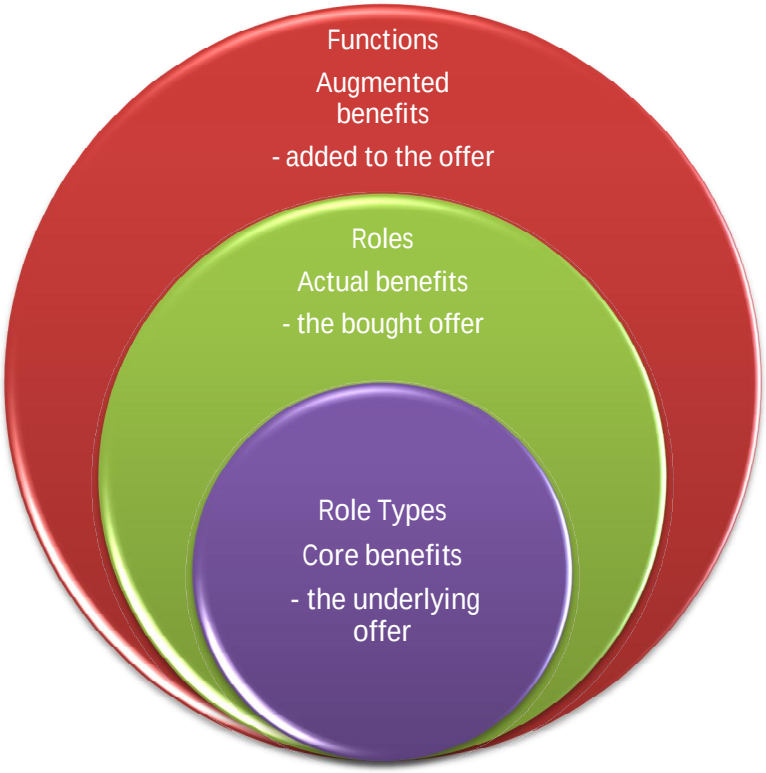


Figure 6: Model for role definition

The resultant model shows distinction between the functions, roles and role types, as being augmented, actual and core benefits respectively. The category of role type is adapted from Druckman (2000), where he defines the underlying roles of consultants in the field of social science research consulting. Consultants aim to allow for deeper, higher order categorisation of consultant types, which will aid the

analysis by providing a bird's eye view of the industry requirements. Druckman's (2000) research was found to be generic enough to be adapted to other consulting fields, as have Nippa and Petzold (2002). The power of defining the underlying role types allows the consulting firms to understand the assumed guise under which they are operating, for example a consulting firm working as a trainer role type when the client requirements are for advisory types will find an immediate disconnect with their market. Druckman's (2000) seven roles are categorised as follows: advisors, technicians, applied theoretician's, study directors, bridge builders, facilitators and teachers or trainers, Table 1 summarises these roles, their names used in this research and their definitions.

Table 1: Generic higher order role types adapted from Druckman (2000)

Role	Role Name	Definition
Advisors	Advisors	Adivsors contribute to the client's strategic, long term concerns
Technician	Technician	Specialist technical skills used to augment the clients staff
Applied Theoretician	Specialist	Specialist knowledge containers used to maintain and grow knowledge in a particular area
Study director	Integrators	Leaders among specialist team members
Bridge Builder	Collaborator	Assists in the linking of specialists with the end users
Facilitators	Facilitators	Assists in aiding of communications
Teachers or Trainers	Trainers	Assist clients in gaining the required skills

The remainder of this research considers both the functions and roles of engineering consultants, as these are deemed to have no distinguishable difference in the view of the client (Nippa & Petzold, 2002), and merely studying roles will not bring significant benefit. A distinction is drawn in the study, between the two, because they possess the attributes of core (bought) and augmented (underlying) benefits.

2.1.3 Comparing private and public sector clients

According to Nutt (2006) the organisational features of public and private clients are fundamentally different. Public sector managers are often faced with the limitations of making strategic decisions, by the disclosure of decisions made, limited budgets and constrained spend on collecting information for the purpose of decision making. Nutt's empirical research concludes with differences between public sector managers placing too much emphasis on bargaining and too little on networking, when compared with private sector managers. In addition, the level of risk considered by public sector managers when compared with private sector managers is lower for the same situation, implying that public sector managers are more risk tolerant. In the context of each client sector view of engineering consulting, it is prudent to consider that these clients may deem the roles of engineering consultants differently.

A focus on the trends facing engineering and the engineering consulting field are addressed in the following sections.

2.2 Project delivery

Clients are seeking broader roles of engineering consultants than merely the supporting ones of the past, they are increasingly being required to be accountable for the total project delivery (Tomaru, 2004), while at the same time finding ways to protect and enhance the natural and social environment.

Increasingly, clients have a selection of procurement options to define the project delivery method (Williams, 2012). The knock-on effect is that the type of delivery

is increasingly defining the new roles consultants play on project-based works. At the centre of these new types of delivery methods, are three fundamental themes; putting the designers, contractors and clients on the same team (O'Farrell, 2010), sharing risk in a more equitable fashion (Wall, 2010), and creating greater value for money from projects.

The most popular types of project delivery models, namely, design-build, alliance and public-private partnership (PPP), all account for the vast majority of proven models. Design-build, which allows contractors to respond to a client's performance specification and enlist the help of consultants to do the detailed design (Perrin, 2012), is the oldest of the three. The alliance structure, which is the newest, allows clients to appoint a single integrated team of contractors and consultants to work in unison with the client to achieve project goals (Williams, 2012). PPPs, are used where the project needs to be financed and managed by private entities, who hand over the turnkey project to public authority (Richie, 2012). The authority would effectively buy the property through a hire purchase vehicle or assign the private entity the responsibility of collecting fees from the users (Department of National treasury: Republic of South Africa, 2012).

The proliferation of these methods have been driven by, the interaction of design and project management in the form of risk management (Wall, 2010). Increasingly, it is becoming central to developing optimal solutions, not only because of the awareness of financial risk, but because the new sources of finance, like PPP require proactive and financially oriented approaches, which are unfamiliar territory for engineering consultants. New risk models like the alliance model share unpredictable risks among those team members who are specifically skilled to address them (Williams, 2012).

The second driver of the new approaches speaks to the globalisation of the construction industry and effective partnering, consortia and joint venturing that make up modern project proposals (Baark, 2001). These create a united team, which avoids the adversarial and unproductive nature of the traditional format of project participants. Moreover, confrontational teams were found to be a major obstacle in successful application of value engineering, and also one of the top

root causes of the projects industry decline (O'Farrell, 2010), lack of integration (Engineers Australia, 2005).

The last of the most significant drivers is fundamental to asset managers, who seek greater value from the delivery of the assets (Williams, 2012), and are increasingly finding that the traditional ways of procuring and implementation are failing to provide shareholders and taxpayers with better returns (Perrin, 2012).

Noticeable benefits have been found from the use of the procurement methods and partnering, which has created beneficial experiences for all entering parties. Some 94 per cent of those surveyed by FIDIC and UNEP (2002), have experienced significant benefits from new relationships. These benefits prove that schedules can be accelerated, costs and claims reduced, risks transferred, and the project delivered on budget (Perrin, 2012).

It is prescribed that the growth in design-build projects is primarily because they free up the client from the technical skills and risks of the project delivery (FIDIC & UNEP, 2002), all via a single contract. The new roles of engineering consultants on these projects will be to work for the client, as opposed to that of previously ensuring efficient management of the contract and maintaining proper relations between the contractor and the client.

Other values from the new methods are attributed to early provider engagement, securing scarce resources and spreading the risk among the alliance partners (Williams, 2012).

Although mostly positive, Baark (2001) warns against the partnering and design-build formats which will ultimately effect innovation in an adverse way.

Eventually, the vast changes within the procurement arena together with the advances in information technology and continued use of partnering and design-build, some foresee the merging of consultants and contractors (O'Farrell, 2010).

2.3 Whole life cycle engineering

The offerings of both small and large firms are being changed by more demanding clients, who are increasingly requiring a more comprehensive range of broad multidisciplinary services with greater involvement throughout all phases of the project (FIDIC & UNEP, 2002). The new requirements from this 'whole life cycle engineering' requires that comprehensive decisions be made during the planning, finance, design, procurement, construction, commissioning, operations, maintenance and de-commissioning stages, rather than previously only in the design stage (Wall, 2010).

The whole life cycle approach in project design is not new, however adoption has been limited. Hindrances to the uptake can be attributed to; lack of information about reliability of equipment, financial aptitude of engineering staff and lack of cost information during the life cycle. Where this approach has been adopted, lack of credibility of the results around findings is also questioned for the same reasons as the hindrance of use.

2.4 Sustainability and CSR

The clients view holds par with that of the literature, as surveyed by Wall (2010). The most important factors affecting clients were; climate change, energy resources, water, urbanisation, demographics and waste, ranked in that order.

In addition, other challenges identified included:

- Needs to move to a low-carbon future;
- Financial and economic crisis and recession; and
- Calls for increased investment in infrastructure, engineering capacity and associated research and development.

Wall (2010) further contends that issues of sustainable development, poverty reduction and climate change are essentially engineering issues, and they have to learn to broaden their objectives from those of the traditional; cost, quality, time

and scope. Broadening of the objectives can only be achieved by maintaining involvement during all phases of the life cycle.

These issues of global proportion have provoked thinking about the sustainability of designs, which involves assessing the impact of the design on environmental, social and other factors, which builds new risk profiling into the design. This will stretch the boundaries of design and challenge the engineering community to be the drivers of innovation.

One of these approaches, will seek to integrate sustainability with globally comparable quality, making globalisation work for sustainability issues will be critical to the strategy of the engineering consultant's mission (FIDIC & UNEP, 2002).

Aside from the sustainability issues, Wall (2010) also suggests corporate social responsibility (CSR) programmes be incorporated into engineering design. While it is fundamental that the social responsibility of business is to increase profits, this perspective pitches business interests directly against society. It is often better understood that the right to make profits are rather a social function given to organisations by the state, hence CSR initiatives give these organisations a 'social license to operate', by justifying the right to make a profit by responding to societies changing expectations from organisations.

It is clear that the traditional roles of engineers need to be augmented by the reinforcing and expanding novel approach that places engineering at the centre of resource conservation and waste management. The shift from the traditional problem solving and design skills will require innovative solutions thinking, which embeds social, environmental, cultural and ethical issues (Duderstadt, 2008).

2.5 Technology: Broader innovative approaches

The challenges of shifts in the workforce and requirements of the global knowledge economy have created the need for broader skills, rather than simply

expertise in the scientific and technological disciplines from engineering consultants (Duderstadt, 2008).

Moreover, challenges from the patchwork of existing infrastructure development, ageing infrastructure system and rapid urbanisation, has created complex and difficult conditions for planning of infrastructure works. This will require new, previously undiscovered approaches from the engineering discipline (Duderstadt, 2008).

Guided by engineers, who have a broad outlook of both science and engineering, technology will create true commitments to the needs of society (Wall, 2010).

The combination of globalisation, information and telecommunications have created a new platform for intellectual work to be created and disseminated from anywhere (Baark, 2001). This creates a new paradigm to the way we do work in both global production and engineering (Duderstadt, 2008).

2.6 Conclusion

Themes within the literature were found to be sparse and at the same time homogenous. Topics found, which relate to the existing and new roles of engineering consultants, dealt primarily with trends rather than specifics, which may be attributed to the newness of the literature searched upon.

The following trends where identified which will influence the role of engineering consultants:

- New project delivery methods;
- Whole life cycle engineering;
- Sustainability and CSR matters; and
- Increasing need for innovation and technology.

New project delivery methods are significantly influencing the roles of engineering consultants, and require changing outputs and increasing visibility of consultants on these projects.

Whole life cycle engineering is very much a supporting facet to the other trends, like project delivery and sustainability; however, it stands on its own in the traditional role and highlights an emphasis that will be critically required for the future.

Sustainability and CSR are initiatives that are not envisaged to disappear; however, they will require conscious efforts to integrate into the design aspects of every project and life cycle support function.

Innovation and technology are cornerstones to the value that engineers create, and although highlighted as part of engineering consulting's humble beginnings, the literature suggests that they have not become the drivers of culture for these organisations.

The trend among these defined aspects is clear, the role of the engineering consultant has been adapted, augmented and supplemented by changing customer requirements; imposed upon by changing landscapes of regulatory, technology and sustainability environments. It is clear that engineers need to move up the value chain (Duderstadt, 2008), and thereby consider a more comprehensive, rounded and holistic view to the work they produce.

The sparse nature of the works from the literature has made it difficult to ascertain conclusively the changed requirements from clients. It is for this reason that a qualitative study was used to supplement the literature. This is discussed further in the research methodology.

2.6.1 Research Question 1:

Investigate whether the list of functions and roles, identified as relevant, differ between private and public sector clients. How do these comparisons set the path for future work?

2.6.2 Research Question 2:

How do relevant functions identified relate to the role types that engineering consultants should adopt?

CHAPTER 3: RESEARCH METHODOLOGY

The research methodology was found to be critical to the core of answering the research questions, more specifically in the case of this topic. The literature review, although abundant, was found to be homogenous and partially irrelevant to this research. To address this shortcoming, an underlying research assumption was adopted, which relates to the collection of more diverse types of data, which would allow for a better understanding of the research problem. Creswell (2003) suggests that the mixed methods approach is best suited to this assumption, more specifically, a sequential qualitative and quantitative approach.

3.1 Research methodology and design

Of the methodologies available for use in this research, the mixed methodology was found to be the most suitable for addressing the research questions. The pragmatic approach characterises the outcomes of the research question which, was found to be fitting with the type and context of the research at hand. This research, which centred around both the exploratory (Sub-problem 1) and measured (Sub-problem 2, 3 and Research Question 1) approaches, allowed for the hybridised, mixed methods approach to harness its benefits to achieving research outcomes, while minimising the drawbacks of the alternative, quantitative and qualitative, approaches (Johnson & Onwuegbuzie, 2004).

The adopted mixed methods approach was based on an exploratory (qualitative) and a subsequent consensus (quantitative) based analysis. First, a qualitative method was used to explore the gaps between the literature review trends and those of the typical southern African power systems client, this allowed for new emergent and contextual factors to be examined. This accumulated information was then combined to serve the content of the survey. Quantitative methods where then applied to the survey data gathered, to draw out information for the research questions. The overall methodology is depicted in Figure 7.

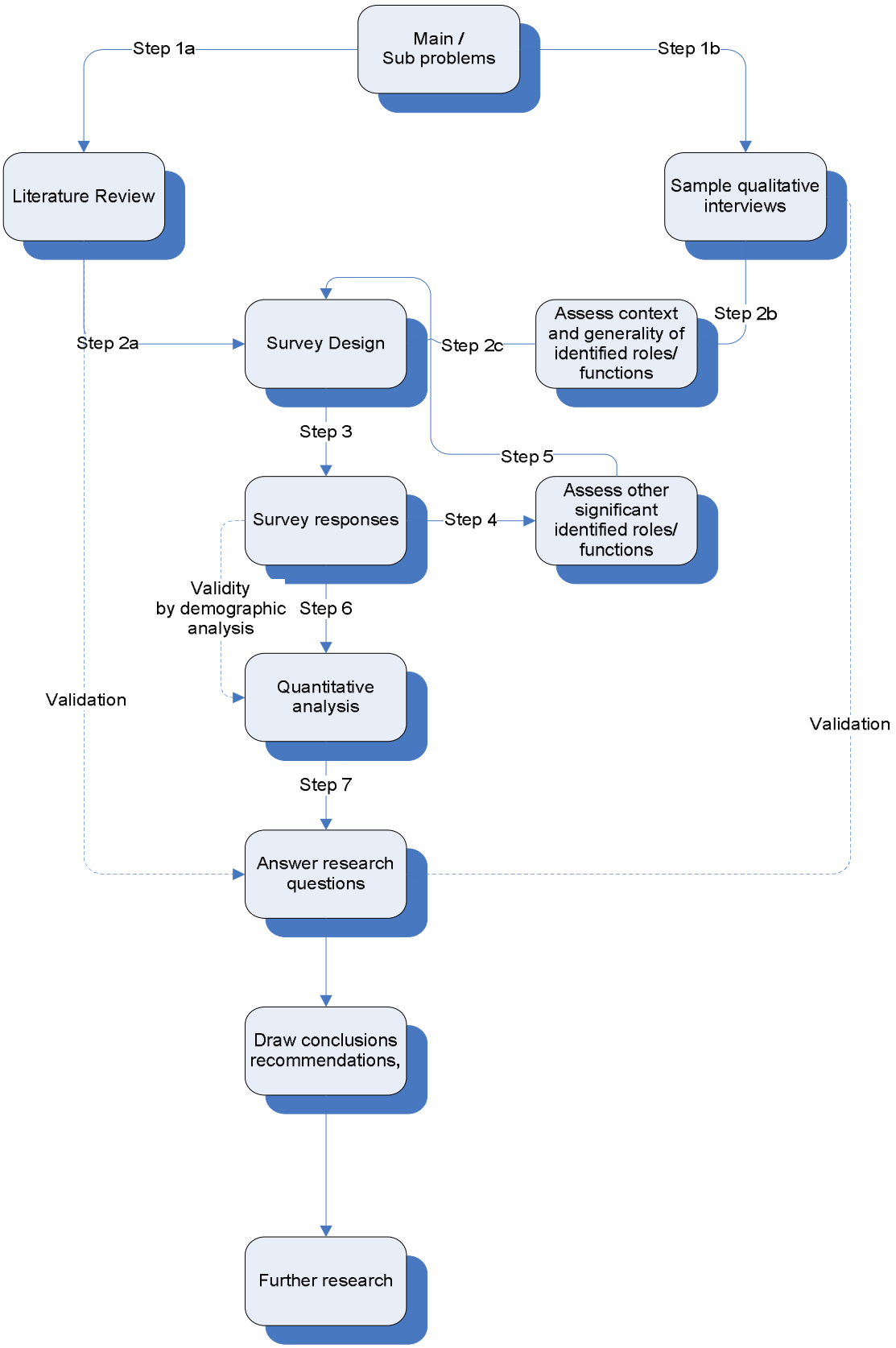


Figure 7: Research methodology

First, the research problems were addressed via a multi-pronged approach of, literature review and qualitative assessments (Step 1a and 1b). Each of these prongs produced a table of roles for engineering consultants. These roles were then rationalised (in the case of qualitative) (Step 2b) and consolidated into a single pool of roles addressable by means of the survey tool (Step 2a and 2c).

Surveys where then sent to clients of engineering consultants to measure the level of importance (Step 3).These same surveys included an option to add to those roles identified, which were not sufficiently addressed by the survey tool. This allowed for the augmentation of the original survey (Step 5) to redress this missing role if it was found to be significant (Step 4). These steps allowed the methodology to build-in reliability but also add to the credibility of the pool of roles by a form of member checking (Kalof, Dan, & Dietz, 2008). Significance was defined as having at least two mentions from the survey pool. Where this was case the survey tool was modified and re-submitted to the recipients. Steps 6 and 7 of the methodology flow chart address the analysis of the survey results, which was based on quantitative methods.

The research method used to achieve the research outcomes were designed to be both practical and simple, while attempting to create comprehensive and detailed conclusions to a field, which does not contain much research.

3.1.1 Qualitative approach: Building the pool of roles

Qualitative methods are best used to gather exploratory and attitudinal data, to address the roles of consultants, by means of open-ended questions (Kalof, et al., 2008), and though much has been gathered from the literature review, it is the researcher's opinion that this will not be sufficient to establish a complete list of roles for engineering consultants. Further to this, literature found did not specifically deal with the changing roles of engineering consultants, instead they were found to be issues around service quality, staff motivation and general trends facing engineering. Data that was gathered from these structured qualitative interviews was synthesised and used to supplement the constructs found in the literature review.

The group of interviewees were chosen based on their roles in their organisations and their diverse fields within the industry. The aim being to establish a broader scope of roles, which could be used to add to those identified in the literature. The data stemming from the qualitative interviews required that a general inductive analysis (Thomas, 2006) be carried out and that the responses be rationalised and consolidated to a list of additional roles identified.

3.1.2 Quantitative approach: Survey data and analysis

The measurement of the perceptions of clients towards each of the different roles of engineering consultants was found to be best suited towards the quantitative research approach; this is due to the ability of the approach to measure narrow, unbiased and known constructs (Creswell, 2003): it is for this reason that the bulk of the methodology revolves around this.

The data was gathered by means of a survey, which is commonly used in this form of assessment, and allows for practical and simple collection and understanding of the data (Kalof, et al., 2008). Practicalities allowed the advantages around the surveys to be harnessed, where it was found that respondents where geographically sparse and time for meetings was short. The web survey allowed respondents to complete the surveys remotely and in their own time, often allowing them to complete it in multiple sittings. The survey was augmented by the addition of a single open-ended question. This question allowed respondents to add to the pool of roles and was discovered to be a useful tool to validating the constructs already included in the survey, the next section discusses this in detail.

3.2 Population and sample

3.2.1 Population

The qualitative contacts were found among the researcher's contacts from working in the industry.

The quantitative population was clients of engineering consultants in the southern African region, in particular, clients specific to the power systems industry were targeted.

3.2.2 Sampling

The qualitative portion of the research was achieved by contacting the researcher's network of contacts to establish a diverse list of persons who are directly involved with engineering consultants in the power systems sector, and were chosen from the public and private sectors, from different levels of the organisations. A single candidate from each of the abovementioned sectors was chosen to allow a diversity of views. Table 2 details these candidates organisational duties.

Table 2: Sample qualitative interviewee profile

	Public Sector	**Private Sector**
Middle Management	Senior Project Engineer City Power	Project Manager Exxaro Renewables
Upper Management	Senior Specialist Eskom Transmission	Programme Director (Power projects) Development Bank of South Africa

The contacts from the customer relationship database, of Parsons Brinckerhoff Pty (Ltd) Consulting Engineers, were used to facilitate the survey process. Clients from the database were contacted and asked to complete the survey. A follow-up email was sent a few weeks thereafter. The CRM database, by design, contains contacts of clients with whom consulting engineers' normally interact. Further categorisations of the clients are already contained within the database, which allowed those clients outside the power systems to be excluded from the survey. The method for sampling would require simple filtering of the database to hone in on the clients who are specifically involved in the power systems sector, and have

had prior experience with consulting engineers. The database contained 105 email addresses, most of which had been used by the firm in recent months, and were validated by a survey done 12 months prior. The initial email was sent in mid-November, after which a reminder email was sent every two weeks. The survey was eventually closed on 15 January 2013, with a total of 32 completed responses (31 per cent).

A second population was obtained, from a recent southern African Power Systems conference, which was hosted by Eskom and attended by both Eskom and other power system clients. The conference was held over two and a half days and a printed copy of the survey was handed out to willing recipients on each day of the conference. Twenty-seven completed responses were received from a pool of 60 persons who were given surveys (45 per cent).

3.3 Research instrument and survey design

The sample of qualitative interviews were conducted on a face-to-face basis and followed by an in-depth interview process. An interview process allows for responses to be collected that the researcher did not anticipate (Kalof, et al., 2008), which were critical to the exploration of new roles and functions of engineering consultants. While the interview took on a structured guise, latitude was allowed for probing questions, which assisted in clarifying the functions and roles identified, and explored the generality of the theme under discussion. The questions asked in the interview are contained in the Appendix A.

The derived survey for the quantitative section was available as both a paper and a web-based survey, see Appendix B for a sample of the survey used. Kalof, et al. (2008) comments that web surveys are by far the most popular of surveys due to their ability to address many persons at once, their relative low cost and the speed of data processing after collection. These forms allowed for practical and convenient completion by the respondent, which was critical to increasing the response rate and avoiding onerous data. Anonymity was another factor that was deemed not only a requirement for academic purposes but also as an encouragement to respondents to complete the surveys without fear of

persecution. The anonymity of the surveys was ensured by a statement from the researcher confirming the use of the survey for academic research and a declaration of not disseminating the individual data samples – requires reference.

Appendix B contains the survey makeup, which was tested against a few interviewees, prior to final communication. This was done to assess any inconsistencies, ambiguities or errors that could create confusion and thereby aid in the reliability of the research. The survey was then produced in two versions, the printed handout version, and an online web survey version with the use of Qualtrics Research Suite. The web based software allowed for the compilation of the survey, management of the incoming responses and reminders, as well as data storage of the captured data. Special features used included:

- No response feature, which does not allow the user to carry on with the survey unless specific questions where completed;
- Email reminders to participants who had not yet completed the survey;
- Export of data collected in Microsoft Excel format; and
- Failed email notice, which allowed for monitoring of defunct email addresses.

On a high level, the survey layout was broken down into the following key areas; social, environmental, economic, financial and political/legislative (Smith & Love, 2001). This categorisation allowed the roll up of the importance of themes relative to each other to become evident.

Questions in the survey made use of a slider scale rather than a Likert scale, this allowed the respondents to visualise their responses while at the same time gathering ordinal data. Ordinal data has been shown to create better reliability and validity of the results (Lozano, García-Cueto, & Muñiz, 2008), than categorical data, which is usually gathered.

The final version of the email surveys was sent out to the contacts, read receipt acknowledgements of the contacts was used to assess the validity of the email addresses. Emails will emanate from the researchers university email address;

this will create credibility, because it confirmed the use of the data only for research purposes.

3.4 Procedure for data collection

Data collection of the qualitative sample interviews were obtained through face-to-face meetings, which allowed the researcher to facilitate in-depth understanding of the answers. The time spent ranged from one to one and a half hours, which was considered reasonable for the four interviews.

Data for the quantitative portion of the study was collected from two sources, the first being the printed surveys handed out at the power systems conference in November 2012. The second was by an online web survey of clients of Parsons Brinckerhoff.

Permission for the handout surveys was first obtained from the organisers, who expressed concern that the survey would not be welcome if participants of the conference were forced to complete the forms. An arrangement was made for the researcher to hand out the surveys, only to those who expressed interest in completing them and further that the respondents completed them in their own time and returned them in the breaks between sessions. Participants were required to complete and return the surveys after each session of the conference, where the researcher was collecting them. A personal and non-intimidating nature was assumed by the researcher, which was hoped to aid in achieving a higher response rate. After collection, responses were captured into Microsoft Excel to allow for easier merging with the web-based results of the survey.

Upon final compilation of the web-based survey, email addresses of power systems clients of Parsons Brinckerhoff where uploaded to the survey tool, where the automated survey monitoring system was used to send out and monitor the responses to the survey. The survey tool allowed the researcher to monitor the response rate as well as when these responses were received. It was observed that immediately upon first sending of the survey and after each subsequent reminder there was a spike in surveys completed. During the time between

reminders, no/little responses were captured. The researcher sent out a further three reminders, every two weeks, to trigger the respondents into action to complete the survey. The survey was finally closed on 15 January 2013, two months after opening, with a collection of 35 completed responses. The responses were extracted from the web survey tool into Microsoft Excel format.

The printed survey responses and web survey responses where combined into a single Excel file, which allowed for direct import into the statistical analysis software, SPSS.

3.5 Data analysis and interpretation

The data analysis function was deemed to be a critical function of the research methodology, owing to the scarcity of research by others on the topic and the specificity of the scope of the research.

3.5.1 Sub-problem 1

Data emanating from the qualitative section of the research was reduced using inductive analysis (Thomas, 2006). This data required that issues relating to a pool of functions and roles identified required stringent verification, because it informed the remainder of the methodology. Repetition of themes, patterns and frequencies at which role and functions where identified. Special attention was given to the respondents interpretation of the themes and also the need to identify themes that were considered generic to the entire industry. The verification was achieved by comparison of this data with that obtained from an open ended question in the survey. Figure 8 details this analysis, which provided an answer Sub problem 1.

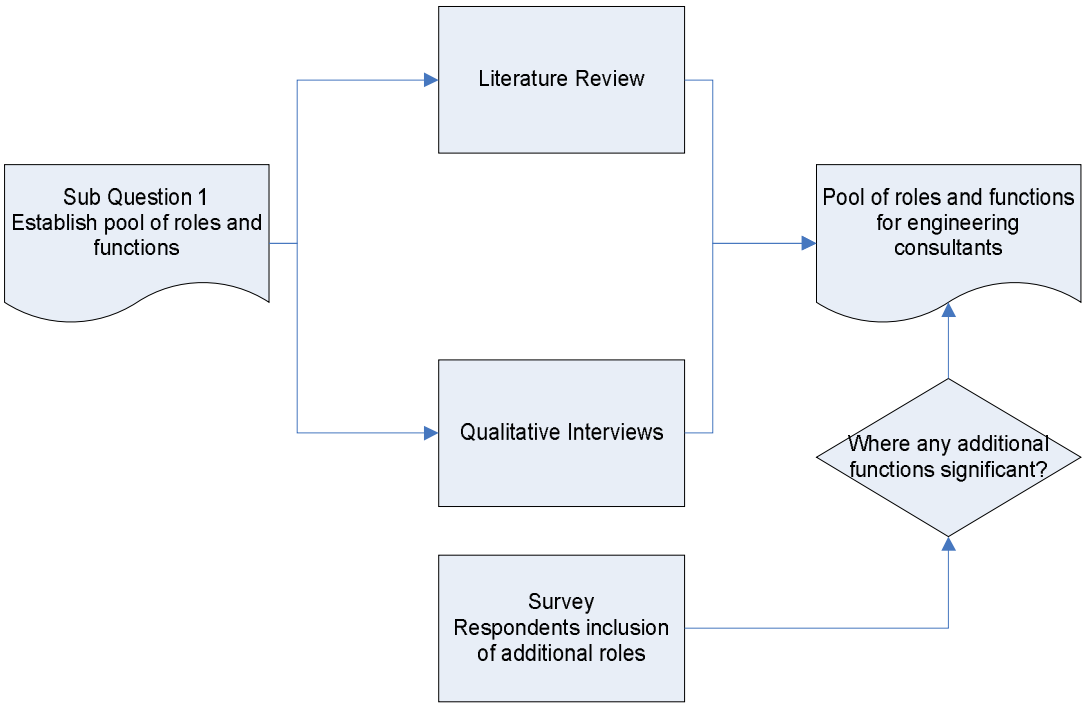


Figure 8: Methodology for gathering roles

3.5.2 Sub-problem 2

The functions and roles identified from the qualitative analysis, were rephrased as questions for compilation of the survey, the final version is contained in Appendix B. The analysis for Sub-problem 2, is depicted in Figure 9.

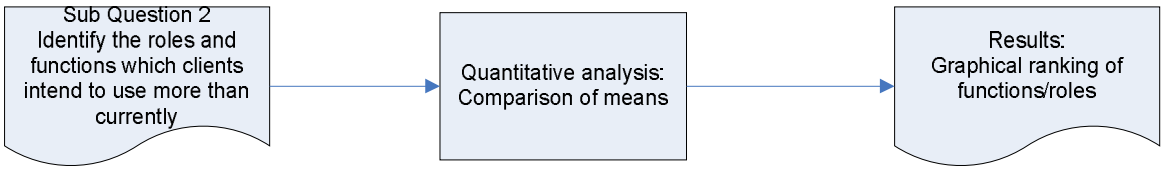


Figure 9: Methodology for ranking roles

Primarily, statistical comparison of means was used to find the differences between the samples. The questionnaire design suited this by way of the format of the questions; each question requiring two answers, first on a level of current use, then on a level of intended use. Typical questions would ask how often the respondents currently used an engineering consultant in a specific role, for example project management and in the same question, how much they intended

to use them in future. This type of data was analysed by both parametric and non-parametric comparisons of means tests. These tests were used to positively identify whether the difference between two means is statically significant or merely chance (Field, 2009). The effect size of the difference in means (which was found to be significant) allowed the statistic to be confidently interpreted by adding the dimension of practical size to the results. Figure 10 details the analysis method followed.

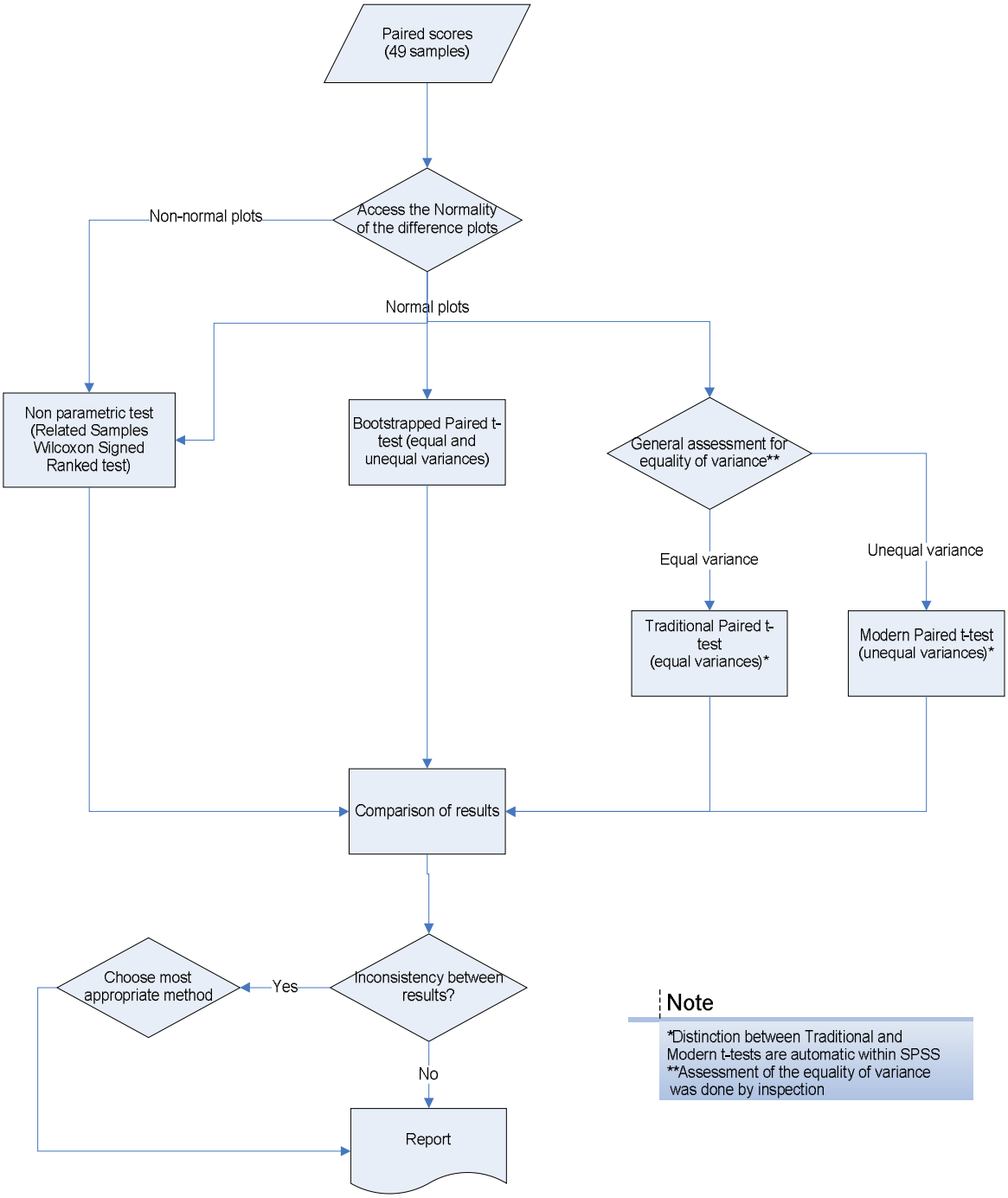


Figure 10: Methodology for analysis of paired data

3.5.3 Research Question 1

Deeper analysis to differentiate the preferences by client type, typically, those from the public versus the private sector were approached as per Figure 11. Public and private clients were subsets of the original sample population, this

required special consideration due to the smaller sized sample populations which would introduce the significance problems associated with low power (Lee, 2012). While the format for comparison of means would be achieved in the same fashion as Sub-problem 2, it was foreseen that with non-significant results, a Multiple ANOVA (MANOVA) test would be required to compare with the comparison of means tests. The results were interpreted to look for significance then effect size prior to comparison. The option of reporting where nothing significant was found was considered.

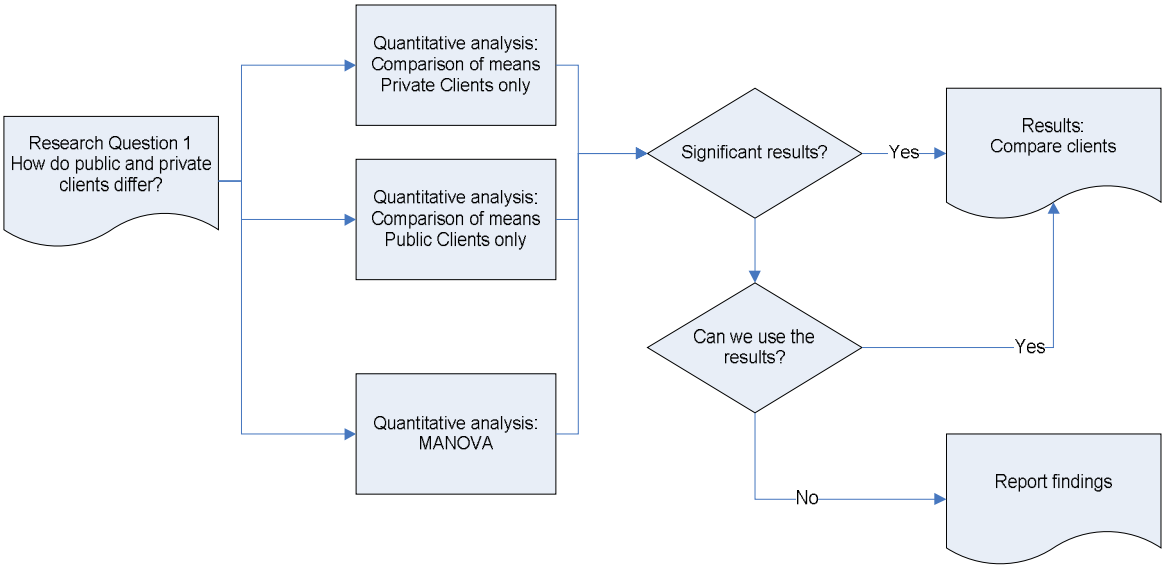


Figure 11: Methodology for client sector analysis

The possibility of the analysis bearing no results was considered due to the size of the sample, therefore as a compromise, the overall means for each client type were used to provide distinction between the private and public clients. As was the methodology for the Sub-problem 2, the means for each question were calculated within that group, the two groups were then compared in terms of their overall means, with the t-test being used to validate the differences.

3.5.4 Research Question 2

Research Question 2 required that role types, as detailed in the literature review be used to categorise the questions in the survey. Questions in the survey would be grouped, such that each group addressed each role type used by consultants.

General interpretation was used to categorise these questions, which often fell into more than one group.

- Advisors;
- Technicians;
- Specialist;
- Integrator;
- Collaborator;
- Facilities; and
- Trainers/teachers.

Figure 12 details the approach used in answering Research Question 2. Assessing the Cronbach Alpha was used to check the group's internal validity (Lee, 2012) by assessing the correlation of the items within the group. A high Cronbach Alpha (>0.65) confirmed the groupings of items. The means of each of the groupings were found, which allowed for comparison, and these were compared with each other for the studies of both current and intended.

The use of the factor analysis was found to be inappropriate for the sample data, which had a sample size of 49. While the Kaiser-Meyer-Olkin measure test results showed the factor analysis to be adequate for the sample data, the Kaiser criterion for communalities revealed the factors could not be extracted when any extractions were less than 0.7 (Field, 2009). Appendix C contains sample results from the initial factor analysis tests, prior to being abandoned.

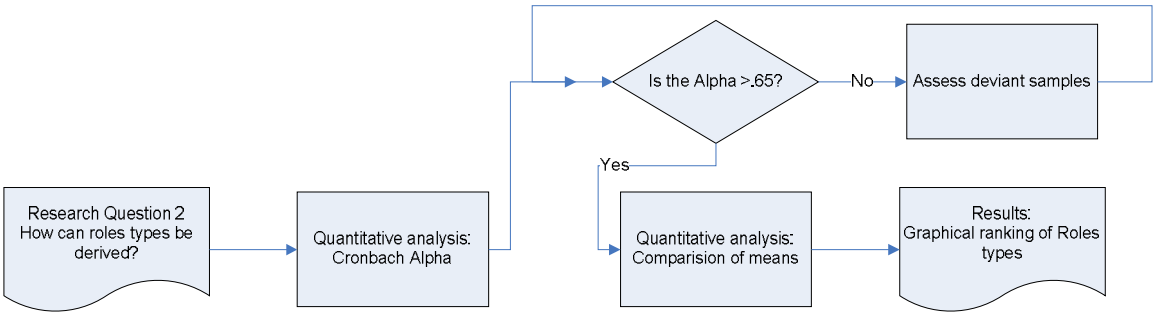


Figure 12: Methodology for role type categorisation

All quantitative analysis was compiled with the software programme SPSS, the use of which greatly assists in time, accuracy and complexity of processing the data.

3.6 Validity and reliability

3.6.1 External validity

This study is uniquely addressed to the field of engineering consulting within the power sector; extrapolation outside of engineering consulting cannot be achieved due to the explicit roles of the consultants in question. This study, however, could easily be adapted to other sectors, such as mining and civil, due to the common nature of the work activity and role requirements.

3.6.2 Internal validity

This study breaks down when it is considered that the qualitative interviews used to add to and refine the survey roles of engineering consultants may not be representative of the southern African based power sector community. All efforts were observed when trying to validate this data, by the use of the surveys, as mentioned in the research methodology. It is still acknowledged that specificity, such as emerging market pressures, geography, and politics, would make significant differences to the validity, attempts were made, by way of diverse samples in the qualitative part of the research, to ensure that the data gathered is as completely representative as possible.

3.6.3 Reliability

Consistency of the data gathered was largely dependent on the language used and the clarity of the questioning, this is due to the possibility of language being an issue for many respondents who do not have English as a first language. Other reliability factors, around the use of technology, were addressed by pilot surveys sent to two individuals with express instructions for feedback on the survey format

and workings. These findings where integrated into the final survey before distribution

Reliability around the pool of roles gathered was addressed in Figure 7 by means of Steps 4 and 5, where a built-in reliability of pool of roles were addressed by the survey recipients, addition of other roles they believed were not sufficiently addressed. Table 2 was based on the data gathered from the survey sample.

CHAPTER 4: RESULTS

The results derived from the research methodology are contained in this section. Discussions related to the results are for the purpose of clarity, validity and reproducibility. Chapter 5 deals with the interpretation of these results in terms of the research questions.

4.1 Sub-problem 1: Generating a pool of functions and roles

The research methodology details the sources for the pool of functions and roles, which were captured from different sources. Figure 8 details the origins of the pool. Table 3 contains the list of functions and roles captured from both the literature review and the sample qualitative interviews. The categorisation of the roles has been adapted from the research of Smith and Love (2001).

The accumulation of the pool of functions and roles are depicted in Figure 13, in which the numbers indicate the number of roles and functions identified after filtering. The filtering of the data for each of these inputs required differing methodologies, as detailed in Chapter 3. In particular:

- The literature review involved simple filtration of roles that presented both a global as well as a southern African context. Literature on the subject was found to be focused only on a few global issues, and little by way of, African contextual issues could be found;
- The qualitative interviews involved an inductive analysis of the data, aiding in richly contextualising the work found in the literature reviews. Filtration of specific issues that were deemed only to be explicit to that individual or organisation were disregarded as being non-generic; and
- The surveys handed out, which were used to gauge consensus, were modified to include an open ended question allowing respondents to enter other functions and roles they considered to be important. These were coded and counted to determine if any were found to be repeated. Unique

samples where disregarded as being non-generic, while others were found to be previously captured.

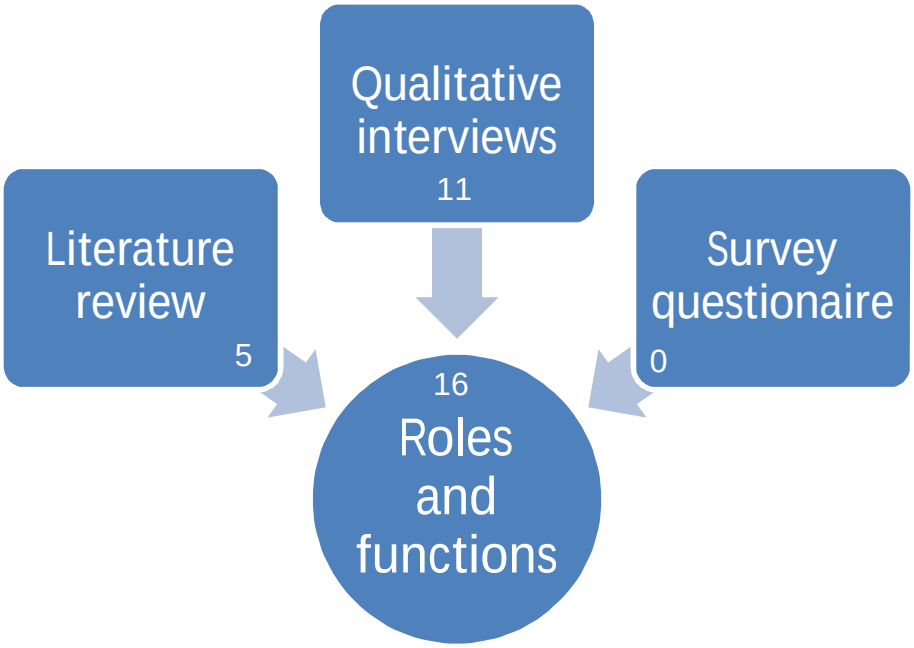


Figure 13: Composition of pool of roles

The multi-pronged approach to obtaining this pool was in defence of the credibility of the pool and aided in obtaining as diverse a pool as possible. A study of the pool revealed that the data contained within, could be categorised as per Table 3, along the following two categories:

1. Functions and roles; and
2. Traditional and emergent.

Roles are commonly an accumulation of functions (Hornby, 2006), and often the distinction between the two are commonly blurred (Nippa & Petzold, 2002). To the consultant they both possess issues of relevance to the client, while the case of functions may be easier to disseminate a focus on. Table 3 presents a division between the roles and functions for the pool. The vast majority of the pool is populated by functions, which may point to the client's emphasis on more than the sellable benefits (roles) of the service offering (Kotler & Keller, 2009), but rather the features of the service offered. This question can only be validated by looking at the rankings of the pool in Sub-problem 2.

Table 3: Pool of roles demographic

Category	Role or Function (Theme)	Role or function?	Traditional or Emergent
Project Management	Project ability	Role	Traditional
	Accountability	Function	Traditional
	Organisational fit and support	Function	Emergent
Economic	Feasibility vision	Role	Traditional
	Specialist and problem solving knowledge	Role	Traditional
	Whole life cycle engineering	Function	Emergent
	Knowledge based work	Function	Emergent
	Increasing need for innovation and technology	Function	Emergent
Financial	Risk management	Function	Emergent
	New project delivery methods	Role	Emergent
	Insurer requirements	Function	Emergent
Environmental	Sustainability	Role	Emergent
Social	CSR matters	Function	Emergent
	Training	Role	Emergent
	Staff retention	Function	Emergent
	Effective teams	Function	Emergent

The research methodology abdicates the augmentation of the pool of functions and roles by those roles introduced from the web survey, which asked respondents to include roles they felt were not sufficiently addressed in the survey.

Table 4 details these functions and roles as well as the number of mentions each included.

Table 4: Roles identified in return surveys

Additional role themes captured from survey results	Count
Teaming up of consultants	1
Locally based core teams	1
Value engineering	1
Legal	1
Financial feasibility	1
Project feasibility	1
Teleconferencing	1
Asset cycle management	1
Defects liability period support	1
Governance	1
Knowledge worker based concepts	1
Risk assessments	1
Localised knowledge	1
Hands on experience	1
Understanding customer processes	1
Fill interim engineering gaps	1

Additional role themes captured from survey results	Count
Project Management	1
Design	1

The results in Table 4 were extracted from the survey samples and coded to allow for tabulation. The table addresses some roles that are new and could be considered relevant in future, however significant consensus could not be found in these cases, in addition much of the table also contains roles already addressed in the original survey, such as project management. None of the roles found here are included into the pool of roles due to the abovementioned reason.

4.2 Sub-problem 2: Assessing growth and intended use

4.2.1 Quantitative preparation

The data gathered from the surveys, required cleaning and careful preparation prior to analysis, this allowed the data to be correctly and accurately analysed. Figure 14 details the breakdown of the survey data as well as the quantity of samples that required removal from the population data.

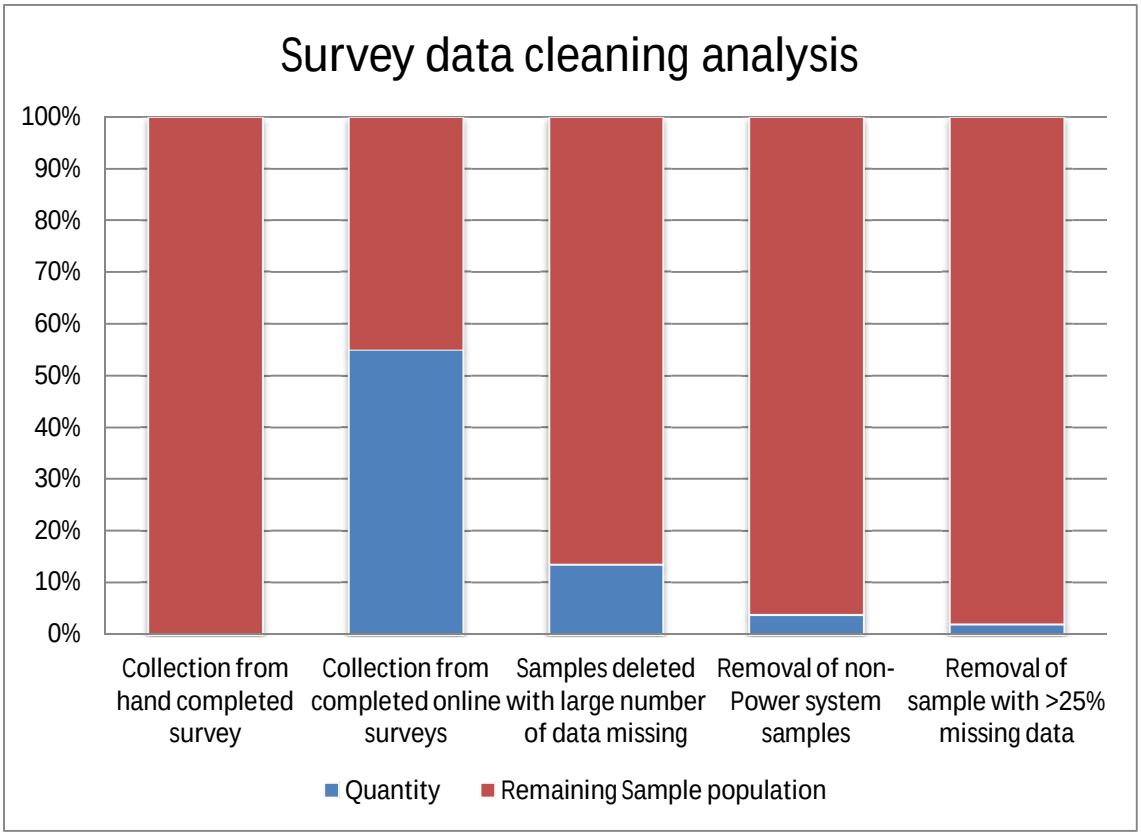


Figure 14: Data demographics and cleaning

As part of the cleaning process, certain samples required corrections due to clear exclusions or errors stemming from:

- Missing employer type details (public or private sector); and
- Clear differences between the amount of interaction of consulting engineers and the number of consulting engineers the respondents worked with. For example, in a single sample where no interaction with consulting engineers was indicated, the answer to how many consulting engineering companies the respondent worked with was greater than four.

Corrections of the data were also required to populate missing data from some samples. Samples having more than 25 per cent missing data were excluded prior to this, and therefore the process only involved a few samples . This correction was motivated by the need to save as much data as possible and the dependence of the analysis on complete paired data samples (Lee, 2012). In total, five of a possible 2156 required correction

The survey was designed to capture the demographics of the respondents in addition to the core questions. This allowed the data to be further subdivided for other forms of analysis and to aid in the credibility of the data. Non-power system respondents where filtered from the set prior to further analysis. Figures 15 to 18, captures these demographics from the survey data.

4.2.2 Survey respondent demographics

1. Respondents positions in organisations

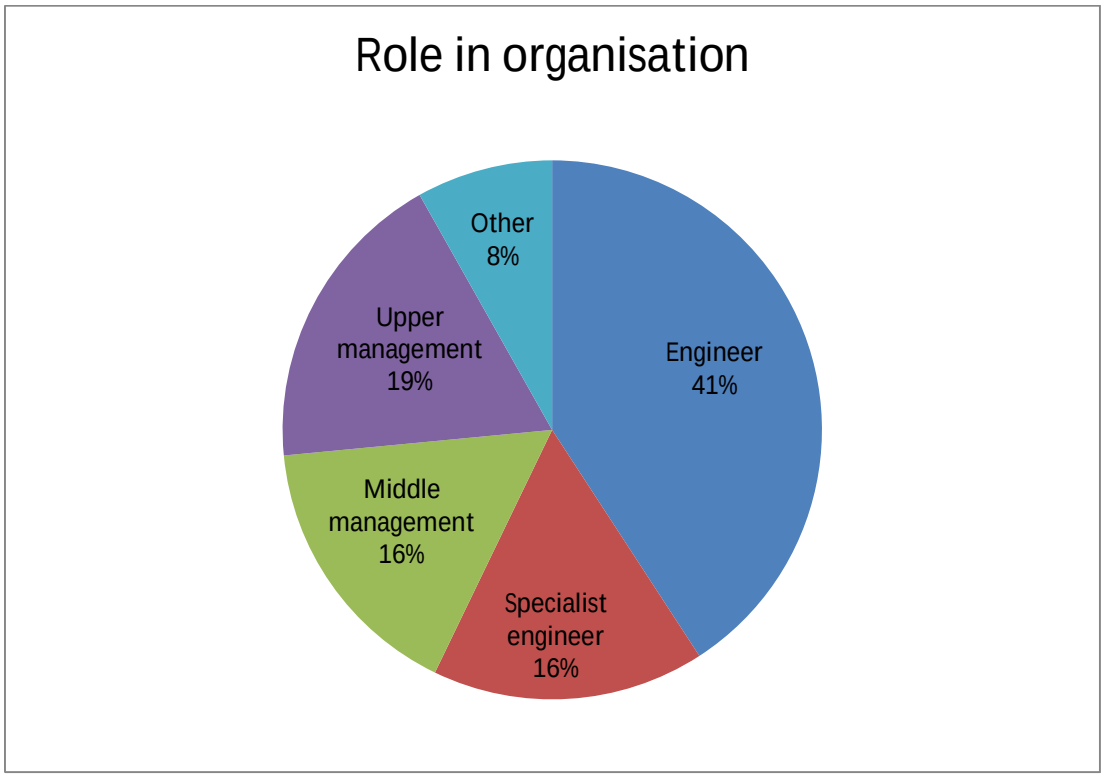


Figure 15: Respondent demographic

The diversity in the demographic for the role of the respondent within their organisation gave confidence to differing views of clients from the same organisation to be observed.

The primary demographic came from engineers (41 per cent) while the remainder of the demographic was evenly split among the remaining demographics. This report does not delve further into these demographics, due primarily to the

number of samples collected; however deeper study into the comparison between the roles and functions that engineers perceived to be important versus those management deemed important, would allow for a better understanding of the overall landscape. Factors such as business-to-business marketing principals and the juxtaposition of strategic versus operational, or long-term versus short-term, are all perspectives that would allow for rich results for further study.

2. Respondents organisation types

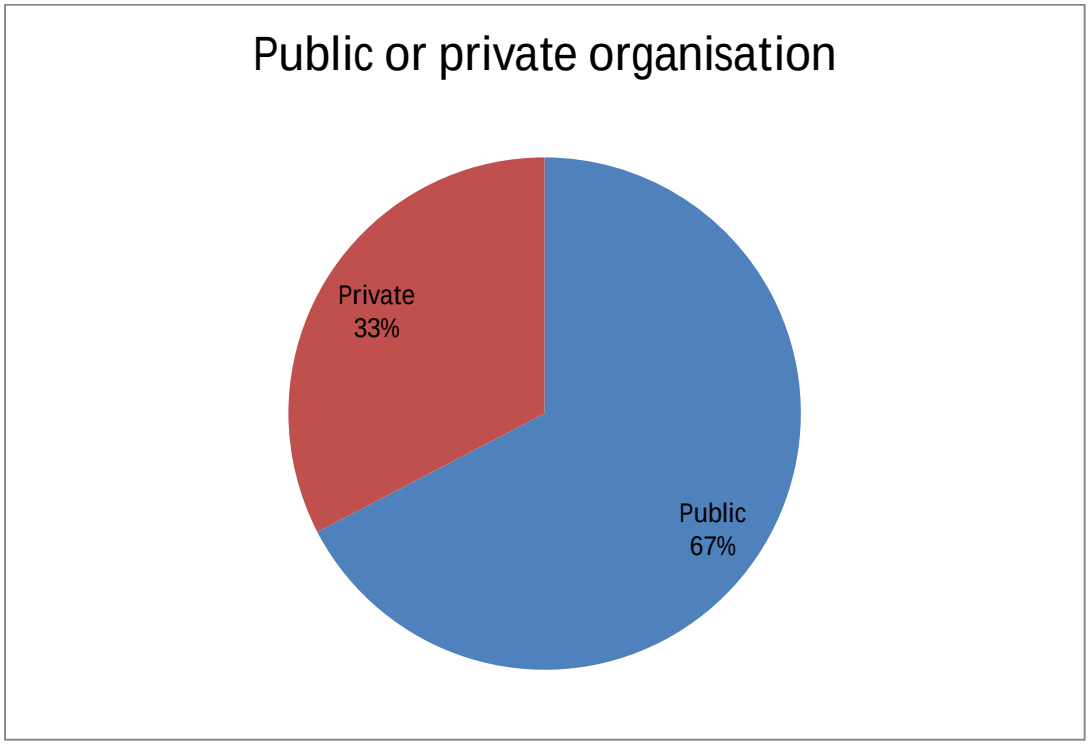


Figure 16: Client sector profile of respondents

The demographic around public and private is a distinction alluded to in the literature review. Analysis around this point is considered in Chapter 5.

The samples collected have a clear bias toward the public client's views, which make up 67 per cent of the sample size. Despite all efforts to gain a more representative sample collection, disproportionate sample sizes are common in statistical sample collection. Tests like those for normality, standard error and p-values allow the statistical results to be interpreted with the credibility and representation of the data in mind (Field, 2009).

3. Respondents amount of interaction with engineering consultants

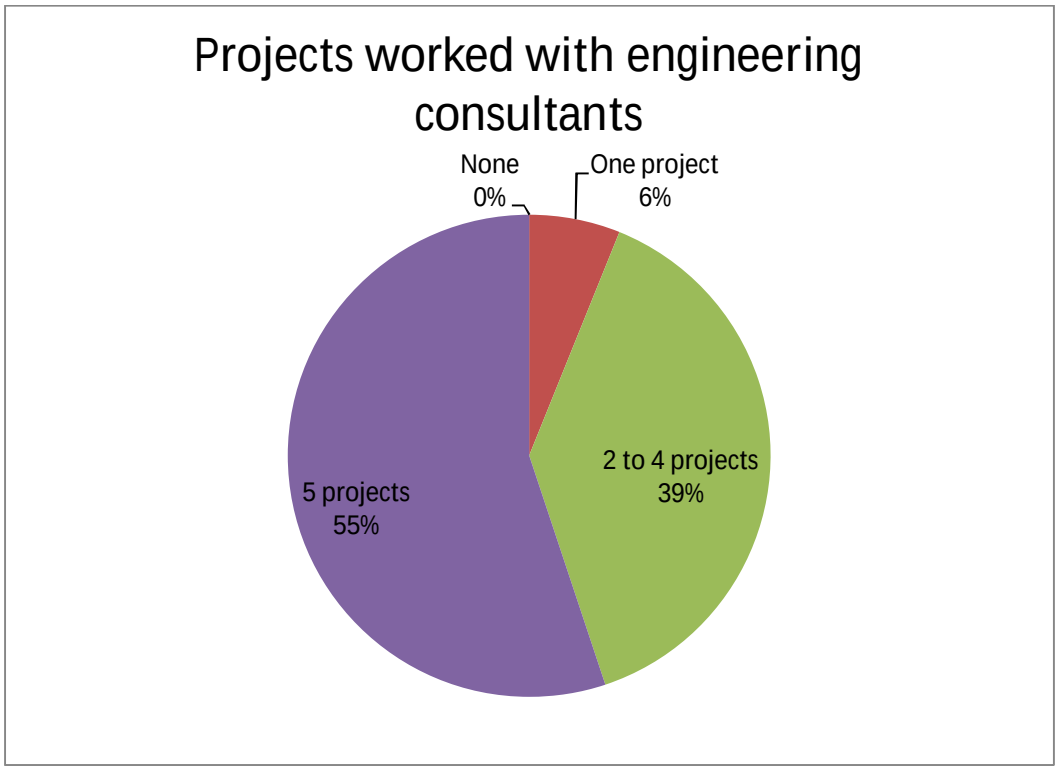


Figure 17: Respondent profile of project interaction

Demographics other than those used to assess groupings, were also used to measure the respondents interactions with engineering consultants. The demographic featuring the number of projects where the client worked with engineering consultants (Figure 17) was used to gauge the credibility of the results. Sample sets with clients who had no experience with engineering consultants on projects would have resulted in the validity of the results being questioned. This sample set reveals all respondents having had some form of project work with consultants, the majority (94 per cent) of which have had extensive project experience (five or more projects).

4. Number of engineering consulting firms engineering consultants have interacted with

The demographic detailed in Figure 18, details a second demographic for the interaction of clients with consultants. The number of engineering consultants with which the clients interacted, was specifically included to address cases where the

clients had no interaction with consultants on projects. The demographic reveals extensive experience with consultants from more than one firm (94 per cent). This introduced validity into the sample set and confidence around the responses not being targeted at a single consulting firm.

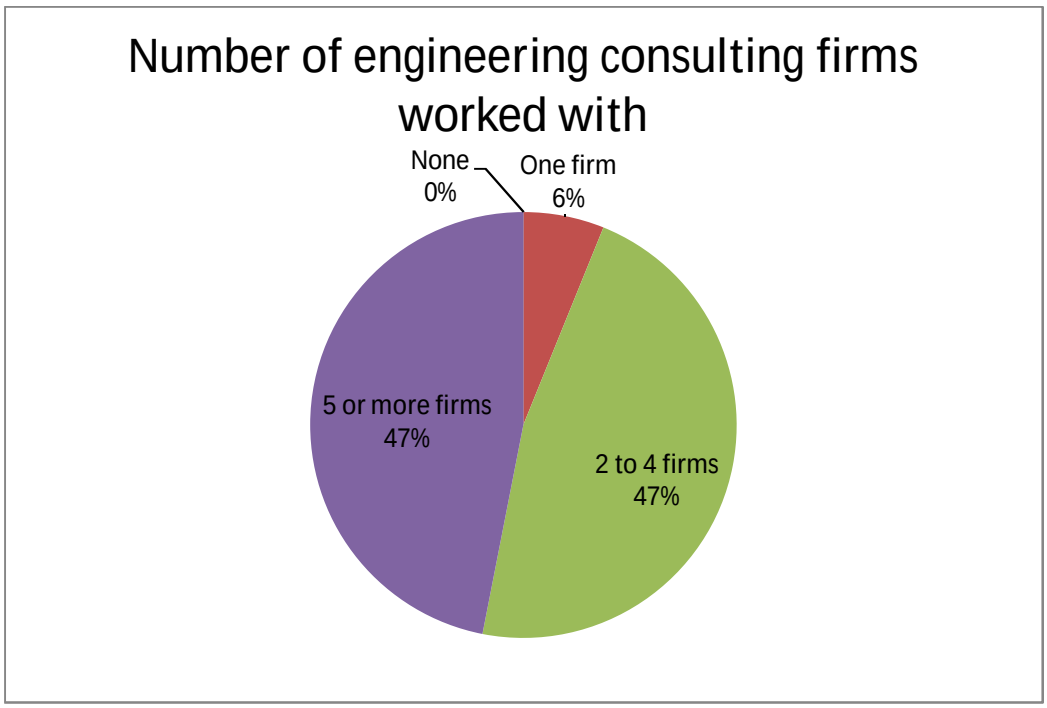


Figure 18: Respondent profile of firm interaction

4.2.3 Sub-problem 2 discussion

The results from the analysis as depicted in Figure 8 are contained in Tables 5 and 6. All results passed the Skewness and Kurstosis tests for normality of the data and seven (Q6, Q12, Q15, Q17, Q19, Q22, Q25) failed either the Komogorov-Smirnova or Shapiro-Wilkonson tests.

Table 5: Normality and variance of data analysis

	Normality of difference plots				Equality of variances				
	Skewness	Kurtosis	Kolmogorov-Smirnova	Shapiro-Wilk	Variance		Sd		
					Current	Intended	Current	Intended	Difference between Sd's
Q5 - Project Management	.27	2.17	.19	.10	468.44	328.74	21.64	18.13	3.51
Q6 - Accountability	-.27	-.43	.03	.17	519.99	467.99	22.80	21.63	1.17
Q7 - Supporting role	-.41	.22	.200*	.53	439.88	413.08	20.97	20.32	.65
Q8 - Organisation processes	-.45	-.78	.13	.02	640.20	519.35	25.30	22.79	2.51
Q9 - Commercial ability	-.47	-.10	.200*	.24	393.87	431.67	19.85	20.78	-.93
Q10 - Feasibility studies	.04	.21	.200*	.96	472.34	448.51	21.73	21.18	.56
Q11 - Specialist knowledge	-.11	.69	.200*	.38	541.14	291.02	23.26	17.06	6.20
Q12 - Problem solving	-.91	1.40	.03	.02	463.96	308.05	21.54	17.55	3.99
Q13 - Life Cycle design	.12	.63	.200*	.17	644.84	485.71	25.39	22.04	3.36
Q14 - Best practice	.34	.15	.200*	.65	439.41	334.28	20.96	18.28	2.68
Q15 - Technology	-.70	.38	.00	.06	515.92	309.15	22.71	17.58	5.13
Q16 - Risk management	.22	-.20	.200*	.77	511.45	457.13	22.62	21.38	1.23
Q17 - Procurement methods	-.49	-.67	.02	.03	618.48	770.14	24.87	27.75	-2.88
Q18 - Insurance implications	.12	.84	.200*	.14	569.31	586.88	23.86	24.23	-.37
Q19 - Value for money	-.88	.55	.03	.01	613.87	415.55	24.78	20.39	4.39
Q20 - Environmental management	-.62	-.08	.18	.05	668.81	571.78	25.86	23.91	1.95
Q21 - Environmental forsight	-.21	-.05	.200*	.63	577.30	486.64	24.03	22.06	1.97
Q22 - Social integration	-.45	-.92	.01	.00	763.17	812.04	27.63	28.50	-.87
Q23 - Training	.01	-.60	.200*	.28	589.30	598.08	24.28	24.46	-.18
Q24 - Retention of staff	-.23	-.90	.200*	.15	651.33	715.80	25.52	26.75	-1.23
Q25 - Team synergy	-.86	.95	.03	.03	583.73	479.21	24.16	21.89	2.27
Q26 - Labour integration	-.52	-.32	.16	.13	673.08	591.63	25.94	24.32	1.62

*. This is a lower bound of the true significance. Sd = Standard deviation

The software used for the analysis, SPSS, does not explicitly display the Levene's test for the equality of variances because this is calculated within the software which also automatically chooses the appropriate method of traditional (equal variances) or modern (unequal variances) to be used (IBM, 2011). To validate this, the equality of variances were assessed by general inspection of the standard deviations (square root of variance), the greatest difference was observed to be 6.2 of 100 (6.2 per cent). On this basis variances were assessed to be equal for the sample set.

Table 6 details the results from the parametric and non-parametric tests. The samples, which failed the normality tests, have been excluded from the parametric tests. The results for both the parametric and non-parametric tests reveal significance of the results and therefore the difference between the means can be considered a significant statistic.

Table 6: Summary of paired analysis

	Descriptives			Parametric t-test		Non-parametric test
	Mean			Un/Equal variance	Bootstrapped to 99% Confidence	
	Current	Intended	Difference	Interval	Interval	Significance level
Q5 - Project Management	55.65	75.37	-19.71	-30.06 to -9.37	-30.86 to -9.04	0.05
Q6 - Accountability	56.73	81.73	-25.00	-	-	0.05
Q7 - Supporting role	60.43	79.29	-18.86	-29.08 to -8.63	-29.02 to -9.47	0.05
Q8 - Organisation processes	53.59	80.06	-26.47	-35.97 to -16.97	-35.55 to -17.08	0.05
Q9 - Commercial ability	61.73	80.00	-18.27	-27.15 to -9.38	-27.53 to -9.55	0.05
Q10 - Feasibility studies	62.69	79.90	-17.20	-26.35 to -8.06	-25.81 to -7.63	0.05
Q11 - Specialist knowledge	63.67	83.94	-20.27	-30.72 to -9.81	-30.12 to -10.21	0.05
Q12 - Problem solving	64.53	82.22	-17.69	-	-	0.05
Q13 - Life Cycle design	54.90	79.04	-24.15	-33.69 to -14.6	-32.8 to -14.25	0.05
Q14 - Best practice	57.71	79.92	-22.21	-31.66 to -12.76	-31.82 to -12.65	0.05
Q15 - Technology	63.51	79.76	-16.24	-	-	0.05
Q16 - Risk management	50.41	77.55	-27.14	-37.23 to -17.05	-35.49 to -16.43	0.05
Q17 - Procurement methods	45.76	68.84	-23.08	-	-	0.05
Q18 - Insurance implications	50.06	74.23	-24.17	-34.27 to -14.07	-33.12 to -14.42	0.05
Q19 - Value for money	54.92	80.69	-25.78	-	-	0.05
Q20 - Environmental management	56.35	74.81	-18.46	-29.06 to -7.86	-27.98 to -8.5	0.05
Q21 - Environmental forsight	51.51	75.78	-24.27	-33.81 to -14.72	-33.59 to -14.96	0.05
Q22 - Social integration	37.51	66.86	-29.35	-	-	0.05
Q23 - Training	40.31	72.86	-32.55	-43.3 to -21.81	-42.02 to -21.94	0.05
Q24 - Retention of staff	34.61	65.47	-30.86	-41.97 to -19.75	-40.82 to -20.08	0.05
Q25 - Team synergy	56.35	76.29	-19.94	-	-	0.05
Q26 - Labour integration	44.80	71.29	-26.49	-35.5 to -17.48	-35.53 to -18.18	0.05

Significance of a statistic does not imply that the statistic is large in practical terms (Field, 2009). The use of the r-value as recommended by Rosenthal and Rosnow (2009) and allows statistics to be interpreted for practical size. Table 7 details the t, df and subsequent r-values for the sample. All the results were found to reveal significant practical differences, due to the r-values being greater than 0.5.

Table 7: Checks for effect size

	Effect Size		
	t-value	**df**	**r-value**
Q5 - Project Management	-5.11	48	0.59
Q6 - Accountability	-6.63	48	0.69
Q7 - Supporting role	-4.95	48	0.58
Q8 - Organisation processes	-7.48	48	0.73
Q9 - Commercial ability	-5.51	48	0.62
Q10 - Feasibility studies	-5.05	48	0.59
Q11 - Specialist knowledge	-5.20	48	0.60
Q12 - Problem solving	-5.92	48	0.65
Q13 - Life Cycle design	-6.78	48	0.70
Q14 - Best practice	-6.31	48	0.67
Q15 - Technology	-5.36	48	0.61
Q16 - Risk management	-7.21	48	0.72
Q17 - Procurement methods	-6.13	48	0.66
Q18 - Insurance implications	-6.42	48	0.68
Q19 - Value for money	-6.78	48	0.70
Q20 - Environmental management	-4.67	48	0.56
Q21 - Environmental forsight	-6.82	48	0.70
Q22 - Social integration	-6.98	48	0.71

	Effect Size		
	t-value	df	r-value
Q23 - Training	-8.13	48	0.76
Q24 - Retention of staff	-7.45	48	0.73
Q25 - Team synergy	-5.88	48	0.65
Q26 - Labour integration	-7.89	48	0.75

4.3 Research problem 1: Comparison of results between private and public sector clients

The method of analysis for the subsets of private and public sector clients involved multiple methodologies as detailed in Figure 12. Attention was paid to the difference in samples sizes (16/33).

Table 8, details the initial tests, for private clients, for normalcy of data, based on independent samples t-tests. The results gave rise to most of the data being found to contain non-normal distributions, which is common in smaller sample sizes, in this case only 16 samples (Lee, 2012). Assumptions relating to the use of the independent t-test were therefore found to be violated, and bootstrapping of the data failed to mitigate this, the results of this are contained in Table 8 together with those of the MANOVA tests.

Table 8: Normality and variance analysis for private client profile

	Normality of difference plots				Equality of variances
	Skewness	Kurtosis	Kolmogorov-Smirnova	Shapiro-Wilk	Levene's test
					Significance
Q5 - Project Management	.211	-.673	.073	.467	.257
Q6 - Accountability	.077	-1.131	.200*	.359	.402
Q7 - Supporting role	-.346	-.758	.200*	.548	.814
Q8 - Organisation processes	-.212	-1.467	.042	.176	.522
Q9 - Commercial ability	-.523	-.605	.200*	.381	.498
Q10 - Feasibility studies	.177	-1.215	.200*	.381	.945
Q11 - Specialist knowledge	.802	.547	.200*	.391	.589
Q12 - Problem solving	-.009	-.408	.200*	.404	.920
Q13 - Life Cycle design	.028	.796	.200*	.698	.477
Q14 - Best practice	.271	-1.353	.200*	.320	.267
Q15 - Technology	-.811	-.117	.027	.122	.665
Q16 - Risk management	-.063	-1.270	.200*	.530	.608
Q17 - Procurement methods	-.935	.370	.200*	.185	.086
Q18 - Insurance implications	-.938	-.240	.011	.043	.742
Q19 - Value for money	-.657	-.310	.061	.211	.426
Q20 - Environmental management	-1.416	2.202	.055	.027	.411
Q21 - Environmental forsight	-.712	1.188	.200*	.714	.665
Q22 - Social integration	-1.065	.226	.001	.018	.803
Q23 - Training	-.165	-.641	.200*	.390	.516
Q24 - Retention of staff	-.189	-1.159	.197	.541	.923
Q25 - Team synergy	-.311	-.784	.200*	.537	.749
Q26 - Labour integration	-.646	-.831	.120	.136	.762
*. This is a lower bound of the true significance. Sd = Standard deviation					

Table 9: Summary of paired analysis for private client profile

	Descriptives			Parameteric	Non-parametric	MANOVA	
	Mean			Bootstrapped to 90% Confidence			
	Current	Intended	Difference	Interval	Significance	Significance	Obs. Power
Q5 - Project Management	58.25	73.63	-15.38	-6.55 to 18.52	0.27	0.44	0.12
Q6 - Accountability	57.88	78.88	-21.00	-6.55 to 18.52	0.41	0.47	0.11
Q7 - Supporting role	61.00	78.00	-17.00	-6.79 to 18.34	0.74	0.74	0.06
Q8 - Organisation processes	50.88	73.88	-23.00	-6.79 to 18.34	0.40	0.50	0.10
Q9 - Commercial ability	64.81	78.63	-13.81	-10.42 to 16.05	0.39	0.35	0.15
Q10 - Feasibility studies	62.19	77.44	-15.25	-10.42 to 16.05	0.73	0.69	0.07
Q11 - Specialist knowledge	67.50	79.31	-11.81	-7.26 to 18.02	0.21	0.13	0.32
Q12 - Problem solving	65.63	74.69	-9.06	-7.26 to 18.02	0.03	0.04	0.53
Q13 - Life Cycle design	53.88	66.88	-13.00	-3.85 to 17.43	0.03	0.03	0.60
Q14 - Best practice	56.94	70.25	-13.31	-3.85 to 17.43	0.14	0.08	0.42
Q15 - Technology	63.88	72.63	-8.75	-8.53 to 14.37	0.05	0.08	0.41
Q16 - Risk management	56.56	70.81	-14.25	-8.53 to 14.37	0.02	0.02	0.69
Q17 - Procurement methods	45.38	58.50	-13.13	0 to 26.64	0.11	0.07	0.46
Q18 - Insurance implications	49.57	63.36	-13.79	0 to 26.64	0.04	0.09	0.39
Q19 - Value for money	56.69	71.00	-14.31	2.06 to 22.54	0.03	0.03	0.57
Q20 - Environmental management	61.33	66.33	-5.00	2.06 to 22.54	0.01	0.02	0.62
Q21 - Environmental forsight	51.75	66.81	-15.06	3.9 to 30.22	0.03	0.07	0.44
Q22 - Social integration	38.88	53.06	-14.19	3.9 to 30.22	0.01	0.01	0.74
Q23 - Training	43.38	61.31	-17.94	1.59 to 25.23	0.01	0.01	0.75
Q24 - Retention of staff	32.00	50.63	-18.63	1.59 to 25.23	0.02	0.04	0.55
Q25 - Team synergy	52.19	66.31	-14.13	0.88 to 20.59	0.23	0.24	0.22
Q26 - Labour integration	48.13	65.50	-17.38	0.88 to 20.59	0.06	0.06	0.48

As is observed, both the results failed to provide conclusive evidence of a difference between all the individual roles of private and public sector clients in this sample set.

The comparison of the overall means, was used to provide some level of distinction between private and public clients. Detail therefore, around how they differ was not possible from this sample set.

4.4 Research problem 2: Comparison of role types

The research methodology detailed the reasons that factor analysis was found inappropriate for grouping the roles into role types which would have allowed for higher order analysis. Instead, Druckman's (2000) categorisations were used to group the roles types to allow for this analysis. Table 10 details these categorisations of the survey questions for the defined role type.

Table 10: Role type question assignment

Role type	Questions applicable
Advisors	13 ,21 ,10 ,19
Technicians	14 ,13 ,15 ,20 ,22
Specialists	9 ,20 ,16 ,22 ,26 ,11 ,14
Integrators	5 ,6 ,25 ,8
Collaborators	17 ,18 ,22
Facilitators	12 ,24 ,25
Trainers/Teachers	23

The validity of the categorisations were assessed by the Cronbach Alpha values contained in Table 11. The role type of trainer/teacher was the only alpha thought inconsistent when considered for current roles, but this changed for the intended version of the role type. This anomaly was considered reasonable, as it would not jeopardise the remaining results.

Table 11: Cronbach results for role type groupings

Role type	Current	Intended	
	Number of items	Alpha	Alpha
Advisors	4	.781	.895
Technicians	5	.847	.907
Specialists	7	.885	.917
Integrators	4	.847	.864
Collaborators	3	.784	.838
Facilitators	3	.650	.850
Trainers/teachers	1	-	-
		Cronbach Alpha	

After evaluation of the Cronbach alphas, the averaged sums for each role type were calculated and presented in Table 12. Current, intended and difference values were calculated for each role type.

Table 12: Role type overall means

Role type	Items	Averaged		
		Current	Intended	Difference
Advisors	4	56.00	78.85	22.85
Technicians	4	55.58	78.36	22.78
Specialists	7	53.17	76.34	23.17
Integrators	5	54.00	76.08	22.08
Collaborators	3	51.83	74.66	22.83

Role type	Items	Averaged		
		Current	Intended	Difference
Facilitators	1	40.31	72.86	32.55
Trainers/Teachers	3	44.44	69.98	25.53

CHAPTER 5: DISCUSSION

The discussions in this chapter stem from the results of the analysis in Chapter 4. Discussions in this chapter follow the format of the research questions.

5.1 Sub-problem 1: Generating a pool of functions and roles

The pool of role and functions identified were found to be comprehensive while at the same time containing issues new to the industry. The absence of other functions and roles cannot be excluded, and therefore the list is not considered exhaustive, but rather a subset. The emphasis on the key roles, which affect most or all clients, gave the study a generic bias rather than being sub-sector specific. This subset is considered to contain the key issues important to clients of engineering consultants in the power systems sector of southern Africa.

While the list is key, it also remains generic, applicable to most clients in the power systems field; this generic stance could explain the number of roles and functions identified (Table 3), which is in itself a significant result. This bears weight when compared, for example, with South Africa's largest engineering consulting firm, Aurecon. Their website (Aurecon, 2013) acknowledges the growing pressures on clients but only advertises their technical roles, which typifies their advisory role type. These technical roles only address a small portion of those roles identified in the total pool, implying that they may not be able to attend to most client's needs.

Roles (and functions) from a diverse audience within the power systems sector were gathered, which introduced diversity, no more than two or three could be attributed to the same facet, which implies that consultants are not considered single service providers. Regarded from a practical viewpoint, consultants cannot offer only one or two of these roles, as this would lack economies of scale, and create additional administration for the client.

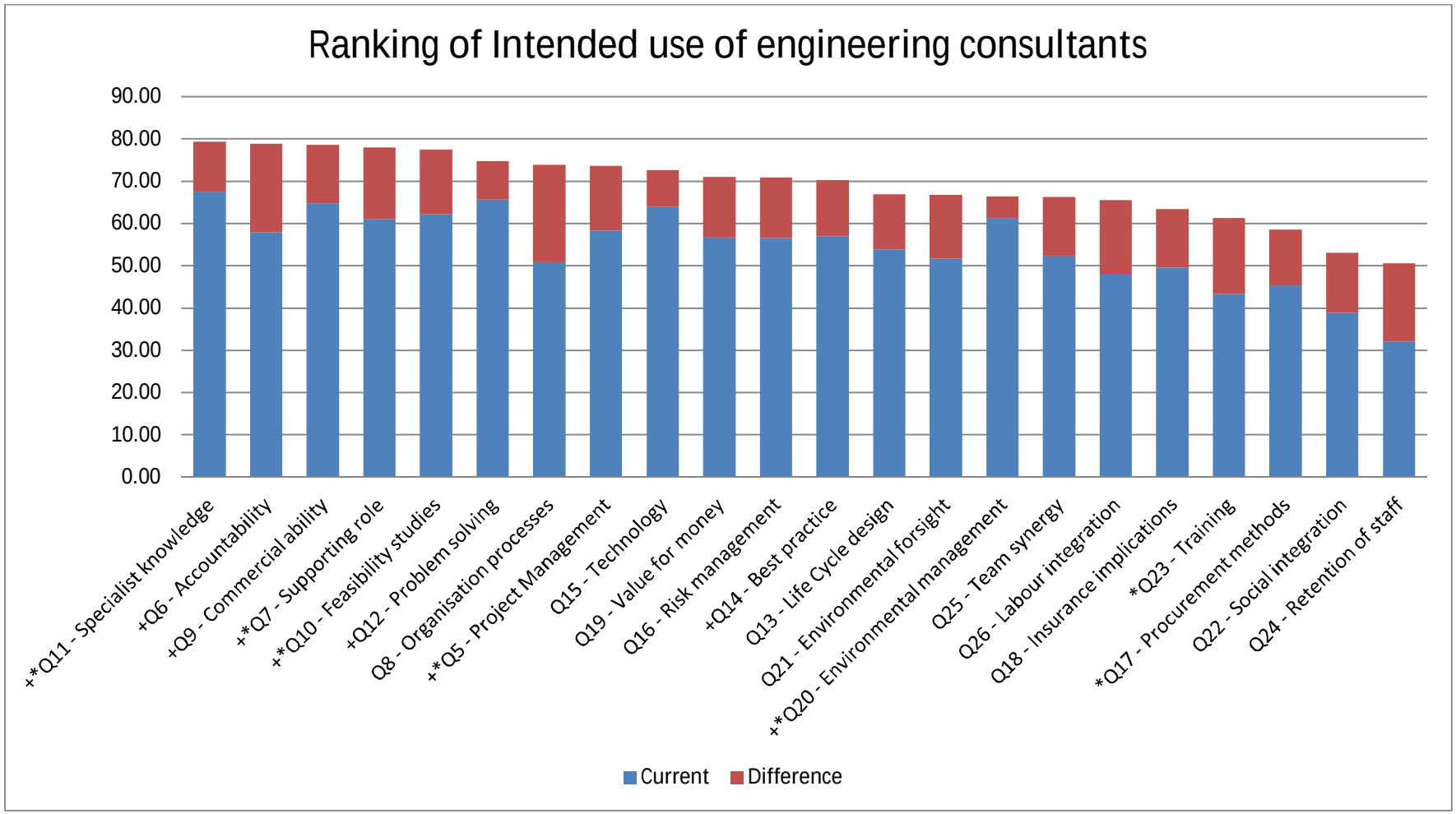
The distinction between sellable (roles) and augmenting benefit (functions) (Kotler & Keller, 2009), gave the pool of roles gathered a dimension which was not

previously considered. The majority of the pool consisted of functions (augmented benefits), which implied that the core benefits of the services offered by engineering consultants are no longer the only reasons clients purchase their services. Increasingly, importance is given to the supplementary functions (augmented benefits), and this is further affirmed by a study of the ranking of these functions and roles.

5.2 Sub-problem 2: Assessing growth and intended use

The graph in Figure 19 is adapted from Table 6, it depicts the ranking of functions and roles based on the mean values of the intended use measure, which, according to the t-tests, have been established as being significantly different.

Overall, the respondents see more use of engineering consultants in future in every function and role identified. Moreover, the average of the entire role differences is 23 per cent, representing almost a quarter more use in the future of consultants in the roles and functions tested. This finding correlates well with the data gather by CESA (2011) for the sector, which places the confidence in the industry around 90 per cent. This result also implies that clients are looking for all these roles to be fulfilled by consultants in future. It is for this reason that the top roles and functions not be overstated as the single saving grace for a firm's success, and a more objective view be considered when placing importance on the most critical roles and functions for an organisation.



*. denotes a role. + denotes traditional roles

Figure 19: Ranking of intended use means

As introduced in the previous sub-problem, the number of roles and functions clients have attributed with being important is significant. None of the roles and functions identified could be considered arbitrary or negligible, as observed by the clustering of the means. The make-up of the survey, together with the results presented in the respondent demographics allowed the collected data to be interpreted as applying to more than one consultant. This implies that the responses to the roles and functions would typically apply to the respondent's interaction with many consultants. In this context, the requirements of clients will get larger (as indicated by the intended measure), and while not all the functions or roles could realistically be fulfilled by one consultant, those consultants who are better at odds to deal with the significant amount of roles and functions will more likely be more successful (Kotler & Keller, 2009).

As discussed in Sub-problem 1, the diversity of the roles identified were considered diverse. In light of all the roles and functions being considered important by clients, this diversity within the pool is confirmed. In further studies of the ratings of the roles, it is noted that although firms like Aurecon are not explicit in their advertising of the diverse roles offered, these may be inherit or unstated in their service offerings. This conclusion is drawn by the fact that none of the roles and functions have a current measure of less than 30 per cent, which implies that this role is currently served, in some fashion.

The top roles and functions are found to be marginally above the rest of the pool, with half the pool within 10 per cent of each other in the intended use measure. This half is populated by, largely, the traditional forms of the consulting function, with roles like specialist knowledge, accountability, commercial ability, supporting roles, feasibility studies, etc. topping the rankings. These fairly traditional roles can be considered the mainstays to the profession and tied back to the origins of the industry (Roberts, 2004).

A second dimension centred around the growth of roles needs to be considered to allow deeper understanding of the results. Table 14, adds the dimension of base values to the rankings, which allows for differentiation on more than one level

simultaneously. This allows for the recognition of emergent and declining roles to be identified, which aid in generating a comprehensive look at the field.

Table 13: Growth off base matrix

		Base mean value (Current)			
		30-39%	40-49%	50-59%	60-69%
Growth	30-39%	Q24 - Retention of staff	Q23 - Training		
	20-29%	Q22 - Social integration	Q17 - Procurement methods Q26 - Labour integration	Q6 - Accountability Q8 - Organisation processes Q13 - Life Cycle design Q14 - Best practice Q16 - Risk management Q18 - Insurance implications Q19 - Value for money Q21 - Environmental forsight	Q11 - Specialist knowledge
	10-19%			Q5 - Project Management Q20 - Environmental management Q25 - Team synergy	Q7 - Supporting role Q9 - Commercial ability Q10 - Feasibility studies Q12 - Problem solving Q15 - Technology

The top left corner is populated by the highest growth off the lowest base, this implies that these roles require the most attention in future. The retention of staff is one that bears the most growth to clients, with growth above 30 per cent off a minimal base of 30 to 39 per cent of current measure. This is not an unexpected statistic, due to the pressures from the lack of engineers in the industry (Toit, 2008). Arguments around the abilities of engineering consultants to respond to and execute this role may raise questions around who is responsible, however, it does not lessen the importance of this role to clients' needs and therefore it should be important to consultants who serve clients' needs. Taking this argument further and drawing down to the definition by Roberts (2004), the purpose of engineering consultants are to reduce overall costs and increase aggregate factor

productivity, by implication the retention of staff is clearly encapsulated in this purpose.

Neighbouring the top left corner is the training and teaching requirement. The role presents a contextual view created by the shortage of skills in the industry, lack of interest in science and engineering and impending ‘brain drain’ of engineering professionals to first world countries (Toit, 2008). The proliferation of engineering technology may be found to exacerbate the situation, by requirements for new training on constantly evolving technology and suppliers. This study may be the first time this construct is measured, but it is not considered unique to the industry. Clearly, training of client’s staff is a key function, which needs to be addressed by engineering consultants, and stands out above any other functions identified.

These new findings provide the consulting firms the opportunity to address this role with strategic intent; allowing first mover positions to capitalise on this finding will see those firms growing revenue in this new category. Hypothesizing the link between this and the second most significant finding, training, could be studied to aid in attempting to encapsulate these into a single finding. Issues around the training of staff and the retention around those same engineering staff could provide valuable information to the industry, the significance of which could be addressed in the context of a study.

Diagonally opposite high growth, low base in Table 14, is low growth, high base roles. A number of roles that populate this space also populate the highest intended use ranking in Figure 19. Most of these are also considered traditional, such as supporting roles and project management. This finding is not surprising because it implies that customers will maintain extensive use of consultants under these roles, but are also increasingly aware of other issues and facets that are emergent on the engineering space such as those discussed in the previous section. These roles present new challenges for consultants who want to fulfil the needs of their clients. What is certain is that the newer roles are being acknowledged as potential to add to the consultants traits and this need will need to be served. Consultants adopting these newer roles will find that they need to

supplement those of the traditional roles, which may also make it more difficult for new entrants to break into the market.

5.3 Research Question 1: Comparison of results among private and public sector clients

The analysis in Chapter 4 concluded that the difference between private and public client samples could not be determined on a per role basis. The sample size was found to be too small to allow this comparison, and therefore any comparison by roles could not be validated or trusted.

A comparison of the overall means between the private and public clients allowed these two categories to be compared. This relative comparison allowed the current and potential of each type of sector to be interpreted. Figure 20, depicts these comparisons and Appendix D contains the t-tests results for the comparisons.

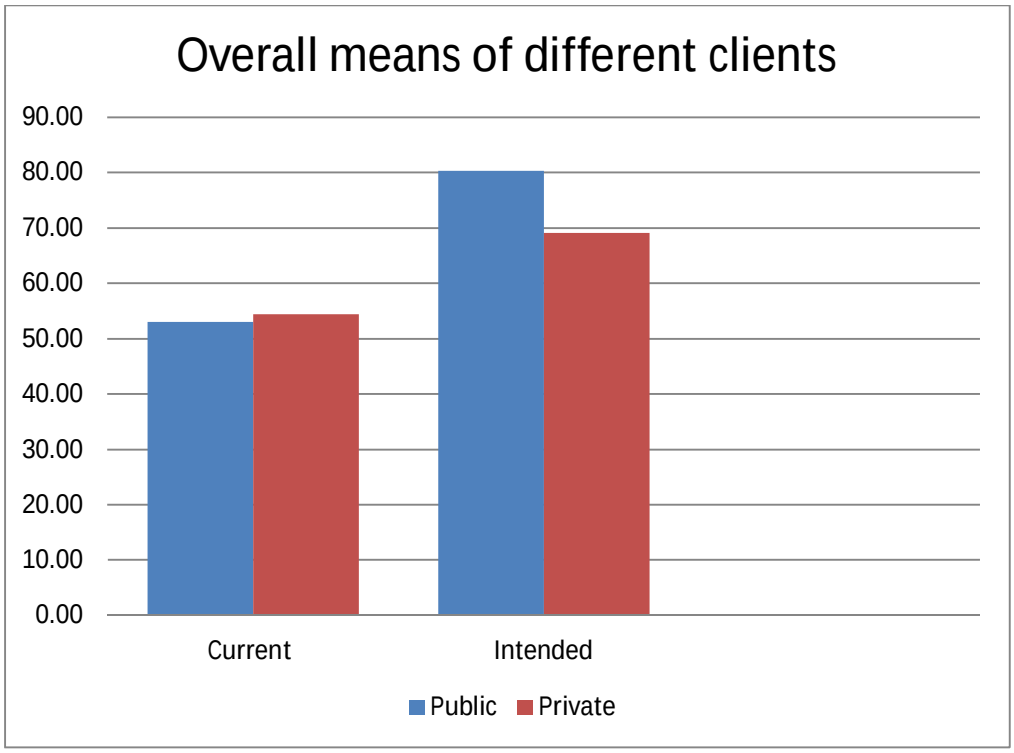


Figure 20: Client sector overall means comparison

The base of current use, only differs marginally between the client sectors; however, the intended use shows significant bias towards public clients, the difference being in the order of 12 per cent. This result ties back to the context of this study and the challenges faced by public sector clients, the importance of the power systems sectors to governments and the overall GDP of countries (Abaidoo, 2011).

The difference allows for an approximate projection to allow this to be related back to revenue terms, entering on a base of R4 billion, for private, and R5.5 billion (June 2011), for public clients, in South Africa (CESA, 2011). Projections for the future of each sector could go to R5 billion for private and R8.3 billion for public in the foreseeable future. This simple projection lines up with the southern African governments' infrastructure spending policies, and describes a growing chasm of increasing revenues from the public sector clients against those of private. The importance of this exercise is not the monentary value, but that the gap between the public and private clients spends on consultants is due to widen.

5.4 Research Question 2: Comparison of role types

Figure 21, adapted from Table 12, details the difference between the varying underlying role types for consultants. Unlike the graph of rankings for the individual roles, this has been ranked by the highest average intended use first, implying that these would be the role types engineering consultants should invest in for long-term strategies.

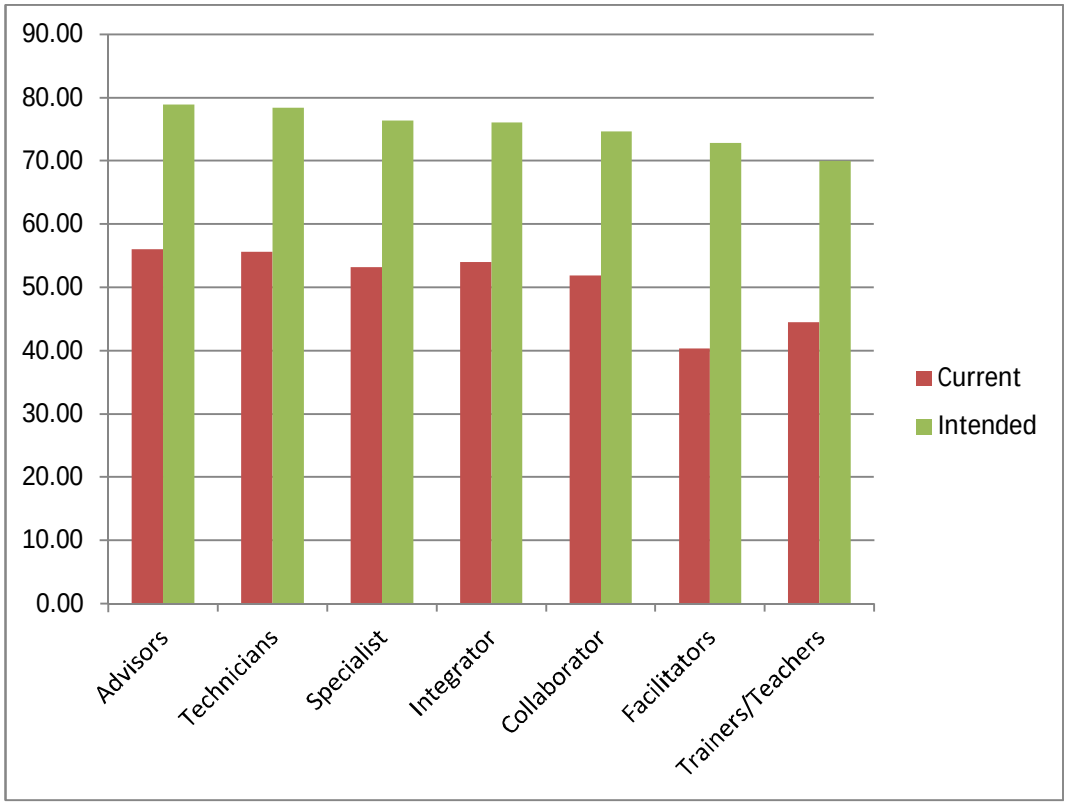


Figure 21: Role type overall mean ranking

On average, all the role types are closely clustered, and differ by less than 10 per cent between the highest and lowest. The role types of advisors and technicians feature marginally among the client's top picks, which is not surprising considering that they address the definition of the engineering consultant. Advisors, relate back to the origins of the industry (Roberts, 2004) and by definition is a synonym for consultant. Technicians are hands on technical specialists, often roles which occupy niche sectors of expertise. These results associate well with those of the ranked intended use for the individual functions and roles.

New role types like facilitators, trainer and collaborator are emerging, as is noted from the relative difference between the current and intended use. Clearly, these are presenting themselves as more prevalent, with the expectation that these may become common place in future. These future role types of engineering consultants are not meant to be focal or specific, but rather a spectrum of varying types, which are called upon when required, and are used to facilitate the work of the consultant (Nippa & Petzold, 2002).

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

Power systems infrastructure is undeniably important to any emerging economy. The facilitation of electrical energy for consumption in the production of goods and services form the basis of good economic planning (Infrastructure & Projects Group Africa Team, 2011). The implications of electrifying areas not previously electrified, allows citizens of the country to be considered inclusive of the economy and regarded. Reliable and expansive power systems infrastructure aids the GDP engine and competitiveness with other emerging economies brought about by increasing globalisation.

Emerging trends in engineering and engineering consulting have come a long way from the profession's humble beginnings. The origin of which lay in machine and manufacturing processes, where gaps in the knowledge and skills required an augmentation of the factory industries (Roberts, 2004). Today, engineering consultants are critical to the execution of projects, playing wide ranging and varied roles with the entire project life cycle (FIDIC & UNEP, 2002). Emerging trends facing engineering are driven by the pressures placed on clients, these pressures range from sustainability and social ramifications (Wall, 2010) to new project financing alternatives, of which, clients are increasingly looking for consultants to fulfil.

The African situation is not unique in its challenges, high potential for growth strangled by low skill levels, are the bane of the southern African context. Increasing GDP levels and low electrification figures point to increasing importance of a good power system ("Where to invest in Africa," 2011). Figures for the engineers per capita are in the order of 6 times their closest emerging market competitor (Toit, 2008). Long-term forecasts require constant repositioning due to this underlying deficiency. Engineering consultants, hold a significant part of the engineering population within its ranks (CESA, 2011). Will its 'economies of

scale' and 'economies of knowledge' aid the ailing engineering function to achieve more with less?

A study of the basic origins of the profession to date, points to an underlying theme, the purpose of engineering consultants have never changed, but they have not stayed the same. Functions and roles identified in its humble beginnings are still being executed today, though today, they are on a different basis. This basis has been augmented and morphed into more technology based work, and higher regard for the issues plaguing clients. The underlying theme is certainly of adaptability in the profession, constantly trying to fulfil the varied needs of its clients.

With the importance of the power systems to economies, the emerging trends in engineering, the southern African challenges and constantly trying to adapt to the changing client requirements, how do engineering consultants filter through the roles they currently serve to focus on those critical to their clients?

6.2 Conclusions

6.2.1 Sub-problem 1: Pool of roles

The depth and diversity of the roles identified were found to be comprehensive, by way of the method of collection, as well as displaying attributes of diversity. Table 3 details the roles and functions found to be key to clients' needs.

The number and diversity of roles were found to be significantly greater than those offered by, even the largest engineering consulting firm, Aurecon, who employ more than 1300 staff (6 per cent of CESA companies' staff population). The roles most under considered were those not relevant to the technical functions of the consultants. This presents a gap from; the perceptions of management of these firms, with the requirements from their clients. Sub-problem 2, delves into the depth and severity of this gap.

A significant portion of the roles and functions in the pool, are augmented products. Their distinction is drawn by the fact that they cannot be sold, but are considered part of a core benefit, which can be sold. This finding is not unique or surprising, because many services are sold on non-core functions, however, the criticality of these are better understood when considered in the context of their relative levels of importance as described in Sub-problem 2.

6.2.2 Sub-problem 2: Analysis of roles

The overall means of the Intended measure (average 23 per cent), clearly indicate a significant need for consultants in the future. In addition all roles were found to be required significantly more in future. This will present great challenges for firms in this industry, who, as observed from their websites, are still misaligned with client perceptions, by only advertising their technical advisory roles.

Formidable growth seen in emerging roles and functions, such as, staff retention and training, will see the future of the landscape of roles of engineering consultants change. The traditional roles like specialist's knowledge, accountability, and commercial ability and feasibility studies will always be a demand from clients, and it is seen that the roles, which are growing will eventually augment those roles considered traditional

The distinction between the traditional and emerging roles are apparent in the ranking of the roles of consultants; top ranked, slow growth roles are traditional ones, while fast growth lower ranked roles are the emergent ones. The finding points to the way forward, and the increasing emphasis on all facets of the client requirements. These trendy demands will place greater pressures on consultants, and will emphasize the increasingly holistic needs clients place on consultants. The increasing homogeneity of importance of the roles will make greater the need to segregate into client types to allow better understanding of a firm's chosen client sector.

Examining the number of roles that clients are demanding, places significant pressure on engineering consultants. Multi-disciplinary firms of consultants will

find favour with clients, as offering multiple services in a single firm, speaks directly to the client's definition of value (Kotler & Keller, 2009). Firms facilitating this challenging need will need to be large or very well networked, facilitating their clients need for a one-stop-shop. The outcome of this requirement could see the polarisation of firm sizes, large firms, which meet all the client's requirements and small niche firms with very specialist knowledge. These smaller firms will primarily facilitate the unfulfilled gaps left by larger firms. This polarisation of firm sizes is a globalisation trend which faces most world economies (Hill, 2005). Partnering is considered a third alternative, as long as still observing economies of scale and efficiencies are observed, and may be viable where the situation allows.

6.2.3 Research Question 1: Public and private clients

In the short term, public sector clients see more need for engineering consultants than those of the private sector. Issues relating to low internal skill levels and capabilities (Toit, 2008), and increasingly ambitious government infrastructure policy expansions (Hill, 2005) are reasons for the drive of this need of external consulting. This will present a deeper chasm between the private and public sectors usage of consultants, driving the orientation of large firms toward the public sector fulfilment, some firms may choose to work exclusively in the public sector in order to better understand and adapt to their clients requirements and thereby increase customer value (Kotler & Keller, 2009). This single focus strategy would need careful consideration of the client, the environment, the competitors, the firms' internal abilities and the potential loss from other revenue streams.

6.2.4 Research Question 2: Assessing role types

The underlying role types of engineering consultants are used to address the consultant's stance or guise on a project; these role types facilitate the consultant in achieving project goals. There is no evidence to suggest that a consultant may not take on many role types on a single project, however, the use of a single role type by a single firm is found to be more effective (Druckman, 2000), this being

due to reducing conflict of interest and overlapping responsibilities. The results show no immediate change from the traditional stances of advisor, technicians, specialists and integrators adopting the highest rankings. Focus on these for the foreseeable future will remain key, while niche stances of facilitators and trainers will see significant growth. Clients will look to consultants who have the ability to adapt to and take up any one of the seven role types as offering a complete service as denoted by the minimal differentiation between all seven role types. Lesser stances may typically be covered by the smaller more specialist firms, as alluded to in the preceding conclusions.

6.3 Recommendations for engineering consulting firms

Consulting firms would need to consider the following recommendations when adapting their services and models for offerings to clients:

a) The firm would need to consider their strategic intent in the industry as a whole. Changing and demanding customer requirements and values are causes for disconnects between clients and firms. In business to business marketing, the better the firms addresses the needs of their chosen clients the more successful their marketing and thereby profitability or revenue is expected to be (Kotler & Keller, 2009). Three guises are immediately available to meet the clients demanding requirements of roles and functions: that of a ‘complete offering’ player, who can address all the needs the client is due to encounter, the specialist player, dealing with the niche knowledge bases or the option of partnering with other firms. Naturally, these guises would need to be suited to the client or project specific requirements.
b) Firms need to adapt to, and build capabilities in previously unconsidered facets that are intimately affecting the client, such as staff retention and training of the client’s staff. Addressing these pressing needs of the client, will allow the firms to gain rapport as client-based rather than product based organisation. This orientation was found to be highly successful with

management consulting organisations (Nippa & Petzold, 2002), significant culture and mindset change would be needed to address this modification.

c) The choice of client sector, public or private, needs careful consideration, in spite of the growth in the needs of public sector clients. A detailed study of the organisation towards either sector needs to include at least a carefully considered environment and competitor scanning analysis, as well as extensive client interviews to gauge appropriateness.

d) Role types of consultants remain reasonably stagnant, and the role type appropriate for the client and situation needs to be instantiated in the appropriate situation. Clients will look to consultants who have the ability to adapt to and take up any one of the seven role types as offering a complete service, or at least offering the niche, complete or partnering alternatives as suggested above.

Engineering consultants are required to move up the client's value chain to achieve more value for clients and address the constantly changing pressures encountered by clients (Duderstadt, 2008).

6.4 Recommendation for clients of engineering consultants

Clients of engineering consultants would need to consider the following recommendations when considering engineering consultants:

a) The fit between consultant service offering and the requirement is not the only consideration for the choice of firm. The consultants' ability to better understand the client organisation's systemic and non-systemic issues would allow those consultants to more closely address the shortcomings within the organisation and forge long term partnering rather than transactional relationships. This longer term partner will bring greater value to the relationship via less effort from the client's side and greater, more tailored outputs from the consultant side, thus increasing the value of the offering (Kotler & Keller, 2009); and

b) Clients are required to expect more from their engineering consultant than just advisor or specialist, partnering with consultants to, for example move into new markets, will allow the unknowns of only the market anomalies to play out. The execution and technical partner relationship will be considered endured and mature. This keeps the risks of the venture to a minimum.

6.5 Suggestions for further research

This study fills the gap of client role requirements of engineering consultants within the power systems sector of southern Africa. Further research, which may aid the industry could be considered in the following areas:

- The same study in other emerging economies such as Brazil and China, would be used to better help the consultants in those countries understand their clients requirements;
- The same study in other sectors of the engineering industry, such as civil or structural engineering, which are themselves experiencing turmoil in their pipeline of revenues;
- Analysis of the clients by demographic groupings would be a valuable exercise, though little literature exists on the differing role requirements of clients within each sector, inferences can be made around the how clients may differ. The outcome of this study may present findings, which will allow the engineering consultant to gather a greater understanding of the clients requirements and thus better service the chosen customer class. Typical demographics that would be useful, would involve, public and private sectors or management (decision makers) and engineering (operational) clients;
- Training and staffing issues occur high on clients' agendas, the implications of this, around the ability of engineering staff to carry out their duties, would provide valuable insight into how much these systemic issues really cost; and

- With the accumulation of more data, analysis around the role types of engineering consultants could be derived from factor analysis. These role types could lead to valuable information for engineering consulting firms around the need for these roles types and the value of each to the client.

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APPENDIX A: QUALITATIVE INTERVIEW QUESTIONS

Instructions to interviewer:

It is important to bear in mind that although we are not talking about attributes like quality of work, level of detail, etc. We understand that this topic is about the roles that consultants should be more involved in. If we find that the attributes are very important in all interviews, then we need to abandon the topic as it stands, and change to something else.

Questions to interviewee

1. What are the current challenges facing your business?
2. How important are the different stages of the project to the client?
3. Importance of different aspects of the project for the client?
4. What are consultants currently doing?
5. What should they be doing? What do you see as the future roles of consultants?
6. How do your think the consultant could be used to assist in these challenges?
7. Why do you think consultants are being used less?

Lower level questions which may eventually appear in the final survey:

1. Do clients still regard technical skills highly?
2. Does the ability to innovate sit more highly than traditional attributes of EC's?
3. Do they see Project Managers in both the client and EC sides as being redundant?
4. Do they see the new sustainability issues appearing more frequently in projects. These are issues around the environmental impact of design, etc.
5. How much ability do clients believe EC have in terms of time, quality and financial of the project so that they can introduce new techniques, technology, social aspects and environmental?

APPENDIX B: QUANTITATIVE SURVEY QUESTIONNAIRE DESIGN

Letter to respondents

Dear Respondent,

I am completing an MBA at the University of Witwatersrand, Johannesburg (Wits). My MBA thesis is on the changing roles of engineering consultants within the Southern African power sector. In an effort to gather data on the subject, I would appreciate 10 minutes of your time to respond to the questions below.

Confidentiality will be observed and your responses will be disseminated and combined with others for academic purposes only.

I appreciate your time and effort.

Kind Regards
Dinesh Moodley
+27 83 445 7484

Survey Questionnaire

The purpose of the study is not to assess the quality of roles that consultants currently fulfil but to rather assess the roles they should be doing. In doing so, the roles that are currently employed with, will be assess together with roles that have been identified as new areas which they should place more emphasis on.

Please indicate your current position within your organisation:
Engineer ☐ Specialist Engineer ☐ Middle Management ☐
Upper Management ☐ Other ☐

Please indicate your type of organisation:
Public Utility ☐ Private company ☐

Please the amount of interaction you have had with consulting engineers:
None ☐ Low (worked on one project) ☐ Medium (2 to 4 projects) ☐
High (5 and more projects) ☐

Please indicate your current work environment:
Power Systems ☐ Other ☐

Please indicate how many consulting engineers you have worked with:
None ☐ One ☐ Two to Three ☐ Four or more ☐

How would you rate the following roles of engineering consultants within the power systems sector?

Please move the slider to you desired position (online version) or mark with an "X" at your desired position (paper version)

Social

1. Social aspects of projects, such as, the ability to incorporate the poverty, employment and communities into the proposal or report

Level of current use	**Low**	[_____]	**High**
Level of intended use	**Low**	[_____]	**High**

2. Ability to train your staff

Level of current use	**Low**	[_____]	**High**
Level of intended use	**Low**	[_____]	**High**

3. Ability to aid in the retaining of your staff

Level of current use	**Low**	[_____]	**High**
Level of intended use	**Low**	[_____]	**High**

4. Ability to integrate easily with your staff, creating team synergy

Level of current use	**Low**	[_____]	**High**
Level of intended use	**Low**	[_____]	**High**

5. Ability to integrate or formulate proposals which integrate local labour into projects

Level of current use	**Low**	[_____]	**High**
Level of intended use	**Low**	[_____]	**High**

Environmental

1. Environmental awareness and integration of this into proposals and reports

Level of current use **Low** [———] **High**

Level of intended use **Low** [———] **High**

2. Ability to look beyond the immediate environmental impact and consider the impact of the designs for the future

Level of current use **Low** [———] **High**

Level of intended use **Low** [———] **High**

Economic

1. Feasibility study reports and its ability to build a clear vision for the future project

Level of current use **Low** [———] **High**

Level of intended use **Low** [———] **High**

2. Technical expertise and expert knowledge in various specialist areas

Level of current use **Low** [———] **High**

Level of intended use **Low** [———] **High**

3. Ability to problem solve

Level of current use **Low** [———] **High**

Level of intended use **Low** [———] **High**

4. Designs incorporate the entire life cycle of the plant approach

Level of current use **Low** [———] **High**

Level of intended use **Low** [———] **High**

5. Ability to innovate and bring ‘best in business’ practice to projects

Level of current use	**Low**	[———]	**High**
Level of intended use	**Low**	[———]	**High**

6. Ability to use and incorporate technology into their work processes

Level of current use	**Low**	[———]	**High**
Level of intended use	**Low**	[———]	**High**

Financial

1. Ability to identify risks and unknowns on projects which could lead to significant costs or benefits

Level of current use	**Low**	[———]	**High**
Level of intended use	**Low**	[———]	**High**

2. Ability to adapt to and encourage new type of procurement methods, such as design-build, alliance partnerships and Public-private partnerships

Level of current use	**Low**	[———]	**High**
Level of intended use	**Low**	[———]	**High**

3. Ability to incorporate insurance conditions into design

Level of current use	**Low**	[———]	**High**
Level of intended use	**Low**	[———]	**High**

4. Ability to create ‘value for money’ offerings to the services they provide

Level of current use	**Low**	[———]	**High**
Level of intended use	**Low**	[———]	**High**

Political/legislative

1. The ability to manage and lead projects in terms of time, cost, quality and safety

Level of current use	**Low**	[_____]	**High**
Level of intended use	**Low**	[_____]	**High**

2. Accountable for the work they produce

Level of current use	**Low**	[_____]	**High**
Level of intended use	**Low**	[_____]	**High**

3. Ability to play a supporting role in projects

Level of current use	**Low**	[_____]	**High**
Level of intended use	**Low**	[_____]	**High**

4. Ability to follow your organisation's internal and procedural processes

Level of current use	**Low**	[_____]	**High**
Level of intended use	**Low**	[_____]	**High**

5. Ability to understand and use the contract's commercial terms and conditions to achieve the project goals

Level of current use	**Low**	[_____]	**High**
Level of intended use	**Low**	[_____]	**High**

Thank you for your time and effort

APPENDIX C: FACTOR ANALYSIS INVESTIGATION

Factor analysis test for adequacy of test

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.827
Bartlett's Test of Sphericity	Approx. Chi-Square	816.872
	df	231
	Sig.	.000

Factor analysis – Communalities Kaiser Criterion >0.7

Communalities

	Initial	Extraction
Q5 Current	1.000	.682
Q6 Current	1.000	.621
Q7 Current	1.000	.627
Q8 Current	1.000	.661
Q9 Current	1.000	.546
Q10 Current	1.000	.694
Q11 Current	1.000	.719
Q12 Current	1.000	.776
Q13 Current	1.000	.558
Q14 Current	1.000	.706
Q15 Current	1.000	.761
Q16 Current	1.000	.720
Q17 Current	1.000	.730
Q18 Current	1.000	.799
Q19 Current	1.000	.761
Q20 Current	1.000	.814
Q21 Current	1.000	.775
Q22 Current	1.000	.699
Q23 Current	1.000	.729
Q24 Current	1.000	.677
Q25 Current	1.000	.758
Q26 Current	1.000	.755

Extraction Method: Principal Component Analysis.

APPENDIX D: OVERALL MEANS OF PUBLIC AND PRIVATE CLIENTS T-TESTS

Analysis of private versus public on overall means

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Private Current - Public Current	1.3937586	3.7425738	.7979194	-.2656056	3.0531229	1.747	21	.095
Pair 2	Private Intended - Public Intended	-11.2308661	5.9142289	1.2609178	-13.8530883	-8.6086439	-8.907	21	.000

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Private Current and Public Current equals 0.	Related-Samples Wilcoxon Signed Rank Test	.101	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.