# ASPECTS OF RISKS IN PETRO-CHEMICAL CONSTRUCTION PROJECTS

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## ABSTRACT

Which construction projects are more “riskier” when comparing projects executed in the petro-chemical environment and projects executed in general, in South Africa? What makes this question difficult to answer is that in previous research, typical risk categories has been identified for construction projects executed worldwide, but from a literature review conducted, it was found that no standard risk categories exist, thus making it difficult to compare the two industries. In this paper we compare construction project risks faced within the petro-chemical environment with construction project risks faced in general and then determine which industry is inherently a more “riskier” construction project environment, in South Africa.

A Qualitative survey-type research was conducted whereby secondary data was collected through an in-depth literature review and primary data collected primarily through electronic surveys, interviews were conducted were practical and through participant observation. Two hypotheses were formulated in order to statistically test primary data collected. *Hypothesis* 1 follows; Construction related risks faced for projects executed in the petro-chemical environment in RSA are similar to projects executed in general and *Hypothesis* 2; Construction related risks for projects executed in the petro-chemical environment in RSA are higher than projects executed in general.

Some of the key findings from the research concluded that the risk management process is clearly defined and accepted as the norm, but no standard risk categories exist in current theory. Hypotheses testing conducted, resulted in the acceptance of both *Hypothesis* 1 and 2, which in turn met the set research objectives.

This paper is of particular relevance to project and risk management disciplines, contributing towards globalization of standard risk categories as well as giving insight into estimating and pricing for risk within the construction project environments. Benefits from this paper include proposed standardized risk categories to be used as a risk management tool for identifying risks, methods of pricing/estimating for risk and a rare insight into the average percentage of contingency allowance allowed for, for construction projects executed in both the petro-chemical environment and in general in South Africa.

**Key words:** construction projects, contingency allowance, risk categories, risk management, petro-chemical environment

## BACKGROUND

## INTRODUCTION

Project Risk Management is one of the nine knowledge areas defined in the project management process by the Project Management Body of Knowledge, 5th edition (PMI, 2013:309). Risk management is an integral part of project management and according to Nicholas J, and Steyn H (2012:371), project management is risk management. Forward planning for projects is a form of risk management. Risk, according to Smith P, and Merrit G (2002:5), is the possibility that an undesired outcome or the absence of a desired outcome disrupts a project, but according to the Project Management Body of Knowledge, 5th edition (PMI, 2013:310) it is an uncertain event or condition that, if it occurs, can have a positive or negative effect on project outcomes. To establish the context of the research, this study will be specific to risks associated with construction type projects. Typical construction project risks associated with construction projects in general was identified by means of obtaining secondary data from the literature review. Two populations' risk similarities and secondly, their risk levels was tested against the hypotheses that projects executed within the petro-chemical environment in RSA carries more inherent risk than compared to projects executed in general.

## CURRENT CHALLENGES IN THE CONSTRUCTION INDUSTRY

The South African Construction Industry experienced a large boom in infrastructure type of projects when the announcement was made by the International Football Federation in 2004, that South Africa had been selected to host the 2010 FIFA World Cup. This was an exceptional achievement for the country, as South Africa was the first African country selected to host such an international event. According to an article in News24 (2006), the cost was estimated at R 2.3 billion for the newly planned 5 stadia in order to have the required capacity to host such an event. The supporting infrastructure, consisted of a bus rapid transit system and the Gautrain, to relieve congestion on already congested public roads with an estimated influx of 450 000 tourists. The actual figures were however far less, reaching only a maximum of 309 000 tourists according to The Daily Telegraph (2010). According to KPMG (2013:24), it was estimated that South Africa would spend R 1 trillion on infrastructure projects during 2014, which included the construction of power stations, revamping Cape Town's international airport as well as a new waste to energy project in Durban. In the coming 20 years, the Integrated Resource Plan for Electricity 2010 – 2030, envisions to reduce energy produced from coal from 90% to 65% and increase renewable energy sources to 9%. This plan will only be possible to achieve if international investors are enticed into partnering with local investors to procure within the domestic market, with spin-off results such as lowering unemployment figures of South Africa. According to Chihuri S and Pretorius L (2010:3), the major construction project risks faced in South Africa during 2010 were: Escalating Costs, Power Shortages and Skills Shortage. They identified the inherent challenges faced within the South African construction industry, which relates to local risk sources which are experienced and which influences the industry. The power crisis and skills shortages are the major local risks faced within South Africa which have been highlighted by both KPMG as well as Solidarity. A survey conducted by Solidarity Research Institute (2010:3), indicated a shortage of engineers as 95% of participating engineering firms indicated that they are struggling to source engineers. Furthermore, this study indicated that in South Africa, there is only one engineer for every three thousand two hundred people, compared to other first world countries with a ratio of one to four hundred and fifty. It is clear that the South African Construction Industry, in general, faces tough times with the dwindling rand and decline in available skilled resources as well as the challenges set by the Integrated Resource Plan for Electricity 2010-2013. Thus the combination of power and skills shortages compared to the South African Government's plans to become less fossil fuel dependent, are not aligned. This will force South African project owners to source scarce skills from abroad, especially with regards to larger, more complex projects. It will negatively affect the cost of design, manufacturing and implementation of technologies in the construction industry in South Africa.

**RESEARCH PROBLEM**

The preliminary investigation suggested that risks are generally categorized according to internal and external sources of risk, but subcategories of risk vary greatly and are not according to set international standards and norms. Trends of construction project risks faced in general are visible from the literature available, and for the purpose of successfully addressing the research problem and meeting objectives, standard risk categories and subcategories were assumed and defined in order to answer research questions and to be able to test hypotheses.

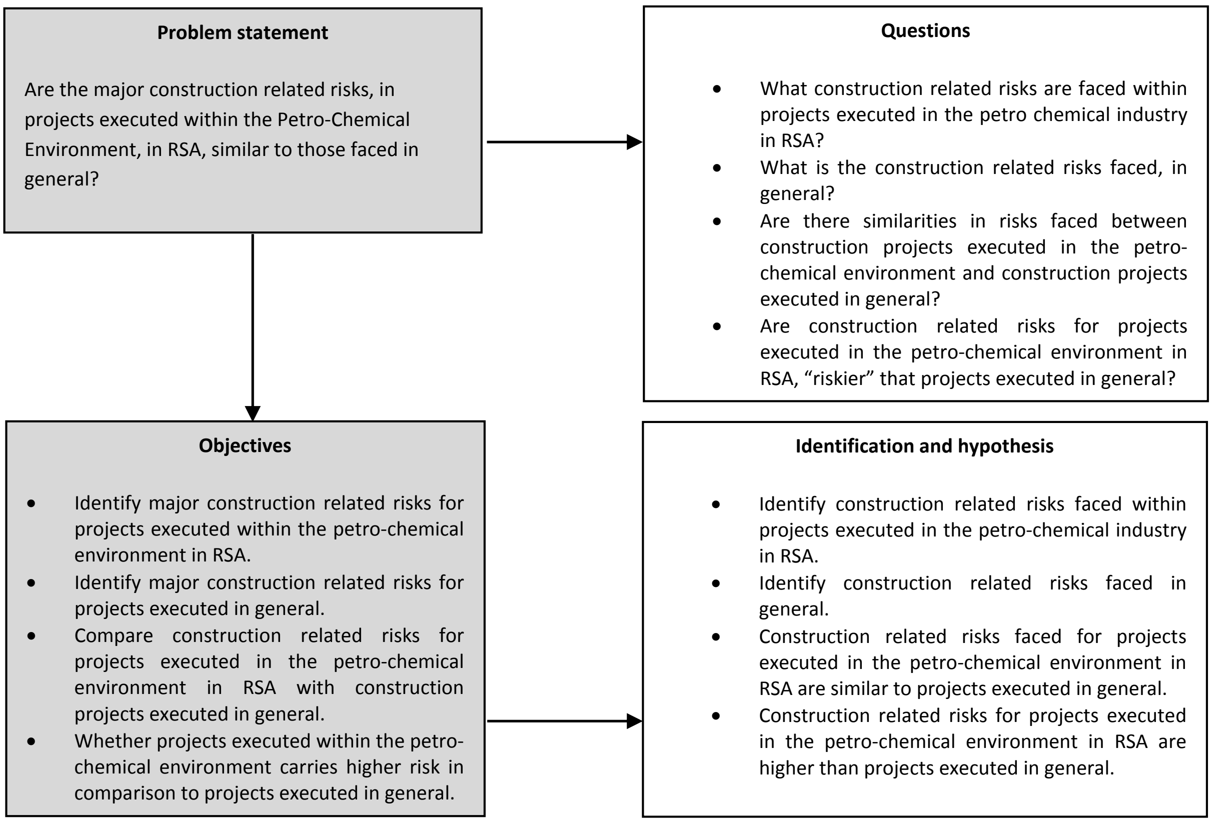


*Figure 1: Summary of the research problem statement and objectives*

**RESEARCH OBJECTIVES**

The objectives of this study are to: identify major construction related risks for projects executed within the petro-chemical environment in RSA and for projects executed in general, compare construction related risks for projects executed in the petro-chemical environment in RSA with construction projects executed in general, and whether projects executed within the petro-chemical environment carries higher risk in comparison to projects executed in general. In order to address the research problem effectively it was necessary to identify and hypothesize the following: identify construction related risks faced within projects executed in the petro-chemical industry in RSA, identify construction related risks faced in general, construction related risks faced for projects executed in the petro-chemical environment in RSA are similar to projects executed in general, construction related risks for projects executed in the petro-chemical environment in RSA are higher than projects executed in general. The risk management process is clear and unambiguous, with the exception that sources and categories of risks, differ from project-to-project, country-to-country. Due to risk being dynamic and unique to each and every project, it is required to identify and conceptualize standard sources of risk, in order to compare both construction projects executed within the petro-chemical environment with construction projects executed in general, in South Africa.

## THEORETICAL FRAMEWORK

### Applicable Theory, Models or Methods

Risk can be defined as the possibility that an undesired outcome or the absence of a desired outcome disrupts a project (Smith P, and Merrit G 2002:5), but according to the Project Management Body of Knowledge, 5th edition (PMI, 2013:310) it is an uncertain event or condition that, if it occurs, can have a positive or negative effect on project outcomes. Akintoye A and Macleod M (1997:3) as well as Baccarini D (2004:1) stated that risks are associated with project costs and that when risk becomes reality, they transfer into monetary profit or loss. Contingency is money and or time added to estimates to reduce the risk of project overruns on project objectives to an acceptable level. These project objectives are cost, time and quality. The construction approximation model proposed by Laryea S, Badu E and Dontwi I (2007:7) indicates that project risk can be directly related to the contingency reserves allowed for during estimation of construction projects. The risk or exposure levels of construction projects can be measured in terms of the amount of contingency estimated for in terms of cost and time. It can be deduced that the higher the contingencies allowed for, the “riskier” the projects are. The risk management process is clearly defined by the PMI (2013:312) which follows the steps: identify risks, qualitatively analyze and rank the risks, quantitatively analyze and define expected losses in monetary terms, develop risk response plans to each identified risk, monitor and control the risks. Risks can be identified using methods and tools such as brainstorming, developing checklists and risk breakdown structures and interviewing project stakeholders (Han S, 2005:9). Risks can be categorized in terms of internal, external, systemic and project specific according to Buerty J, Abeere-Inga E and Kumi T (2012:416). Han S (2005:9) however categorizes risks slightly different in terms of internal, external, local and global risks. Chileshe N and Yirenkyi-Fianco A (2011:118) as well as Nicholas J, and Steyn H (2012:353) categorize risks as being internal and external. Kindinger J and Darby J (2000:959), categorize risk factors as technical, schedule, cost and budget risks. Both Han S (2005:9) and Buerty J, Abeere-Inga E and Kumi T (2012:414) proposed the use of risk breakdown structures which are quite similar. As each project is unique, the risk breakdown structure for each will differ and be project specific. The most popular method for analyzing risk is the standard risk model (Smith P and Merrit G, 2002) and failure mode affect analysis which is discussed by Buerty J, Abeere-Inga E and Kumi T (2012). Buerty J, Abeere-Inga E and Kumi T (2012:414) however stated that the failure mode effect analysis is more systemic and should identify all the risks in comparison to models based on the decision theory. Decision type of risk analysis tools includes decision trees, influence diagrams and risk ranking as listed by Han S (2005:9-17). By making use of the standard risk model and combining it with the construction approximation model by Laryea S, Badu E and Dontwi I (2007:7), enterprises can estimate the risk allowance or contingency in terms of monetary values or time according to the loss expected. With failure mode effect analysis, project risk can be ranked according to the project RPN (risk priority number). Kindinger J and Darby J (2000:959) proposed the use of the Risk Factor Analysis technique which simplifies the risk management process in order to identify the underlying factors that drives behavior of top – level schedule, cost and quality measures of a project. One of the risk responses defined by Smith P and Merrit G (2001:104) was to provide redundancy and or mitigate the risk by providing contingency reserves when estimating cost and schedule. Many authors have researched the different types of risk management tools; it is however the choice of the applicator and user to decide which tools will be most suitable for their application.

**Assumptions and Limitations**

The research is limited to risks faced in South African construction projects executed in the petro-chemical industry in Secunda and Sasolburg areas, and South African construction projects executed in general. It will be assumed that organizations, in general, make use of some form of systematic risk management process in order to identify and manage their construction project related risks. The following risk categories was assumed, based on the literature review and adapted from Han S (2005:9), and used for categorizing risks faced in construction projects executed in the petro-chemical environment in South Africa and projects executed in general. The project risk categories assumed was: internal risks such as local risks; plant, labor, site, subcontractors, material and global risks; client, contractual, environmental, management, design and financial. For the completion of the research, external risks as well as internal, global risks; location, pre-contract, timeframe and construction was not considered to answer research questions as it will not add value in order to meet research objectives.

**Hypotheses**

The following hypotheses were formulated: *Hypothesis* 1; Construction related project risks faced during execution of projects within the petro-chemical environment in RSA are similar to risks faced for projects executed in general and *Hypothesis* 2; Construction related risks for projects executed in the petro-chemical environment in RSA are higher than projects executed in general. *Hypothesis* 1 is a null-hypothesis as it predicts that there is no variance in the two populations (Welman C, Kruger F and Mitchell B 2005:27). *Hypothesis* 2 is a directional hypothesis as it predicts the outcome of comparing the two populations (Welman C, Kruger F and Mitchell B 2005:26). The hypotheses will be tested by means of qualitatively analyzing primary data obtained through observations, survey-questionnaires and semi-structured interviews. To meet the objective, it was necessary to define which one of the two populations was inherently more “riskier” than the other.

## METHODOLOGY

### Research Strategy and Design

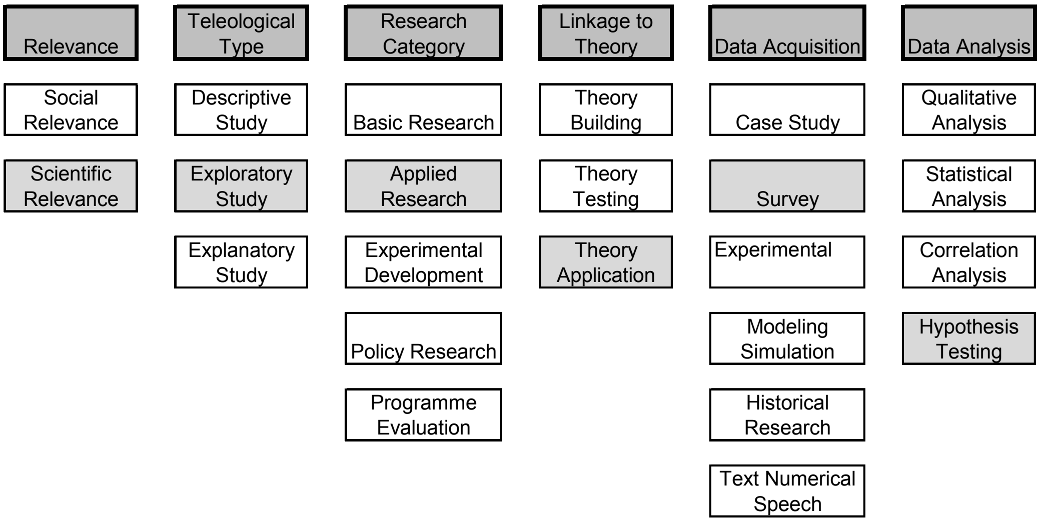


*Figure 2: Summary of Research Approach/Design*

Figure 2 depicts the research approach and design followed during this study. In Table 1, the research questions are listed and research variables constructed and identified which require measurement in order to test both Hypothesis 1 and 2.

| Research Questions | Hypothesis | Research Variable/Construct | Measurement Level |
|---|---|---|---|
| Question 1: What construction related risks are faced within projects executed in the petro chemical industry in RSA? | *Hypothesis 1:* Construction related project risks faced during execution of projects within the petro-chemical environment in RSA are similar to risks faced for projects executed in general. | Construction project risk categories in petro-chemical environment | Nominal Scale ("Yes", "No"/Category) |
| Question 2: What is the construction related risks faced, in general? | | Construction project risk categories in general | Nominal Scale ("Yes","No"/Category) |
| Question 3: Are there similarities in risks faced between construction projects executed in the petro-chemical environment and construction projects executed in general? | | Construction project risk categories in petro-chemical environment : Construction project risk categories in general | Nominal Scale ( Risks in petro-chemical environmemt (Sum "Yes"/Category) / Risks in general (Sum "Yes"/Category) |
| Question 4: Is construction projects executed in the petro-chemical environment in RSA, "riskier" than projects executed in general? | *Hypothesis 2:* Construction related risks for projects executed in the petro-chemical environment in RSA are higher than projects executed in general. | Risk exposure levels in petro-chemical environment according to assumed risk categories | Interval Scale ("Low", "Medium", "High"/Category) |
| | | Risk exposure levels in general according to assumed risk categories | Interval Scale ("Low", "Medium", "High"/Category) |
| | | Risk exposure levels in petro-chemical environment according to assumed risk categories : Risk exposure levels in general according to assumed risk categories | Interval Scale ( Risk exposure levels in petro-chemical environmemt (Sum "Low","Medium", "High"/Category) / Risk exposure levels in general (Sum "Low", "Medium, "High"/Category) |
| | | Percentage monetary contingency allowances estimated in petro-chemical environment: Percentage monetary contingency allowances estimated in general | Ratio Scale ( Percentage monetary contingency allowance estimated in petro-chemical environment (%)/ Percentage monetary contingency allowance estimated in general (%)) |

*Table 1: Construction of variables/constructs*

**RESEARCH SAMPLING AND METHODS**

The appropriate sampling method identified for survey-type of research is self-selection sampling which is a non-probabilistic sampling method. This sampling method is used where the researcher identifies individuals in the desired populations to take part in the research, the individuals then have the choice to take part due to their desire and or opinions towards the research objectives (Welman C, Kruger F and Mitchell B 2005:69). The unit of analysis for the research is construction projects. The population defined is construction projects executed within South Africa. The sampling frame is construction projects executed within the petro-chemical environment in South Africa, limited to projects executed in the Secunda and Sasolburg regions and projects executed in general in South Africa. A self-selected sample was drawn from these geographical locations for the research study. According to Buys A (2012) and Walwyn D (2013), the minimum sample sizes for quota or non-random samples are 136, with a confidence interval of 10%, a confidence level of 90% with a design effect of 2.00. For simple random sampling from a population, the design effect is 1.00, reason being that the probability of being able to generalize to the population is 90%. For self-selected, non-random sampling, the generalizability decreases, to compensate there for, it is required to double the amount of samples from the self-selected, non-random sample to be able to generalize the findings with a 90% probability of being correct.

**DATA COLLECTION AND MEASUREMENT METHODS**

Figure 2 indicates that data acquisition will be conducted by survey-type research. The survey types that were implemented to collect primary empirical data included electronic surveys, semi-structured interviews and observations. The measuring instrument implemented was a survey questionnaire which included nominal and interval measurement levels (see Table 1). Firstly, each construction risk category was identified as a risk or not a risk, if the risk category has been chosen as a risk, then secondly, the risk level was measured by rating scales of “Low”, “Medium” and “High”. Rating scales, according to Welman C, Kruger F and Mitchell B (2005: 159), measures the behavior of participants and are ranked accordingly. For this research, the risk exposure levels of construction projects will be ranked, and not the behavior of participants. The second data collection method utilized was semi-structured interviews whether being telephonic and or personal; it depended on the practicality of geographical location of the respondents. The structure of the interviews was based on the questionnaire survey. Participant observation, according to Welman C, Kruger F and Mitchell B (2005: 194), is where the researcher becomes involved in cases over a longitudinal period of time and actively participates and observes cases being studied. This is a subjective approach in data gathering techniques (Walwyn D 2013). For the researcher, it was possible to act as a participant observer as the researcher forms part of the petro-chemical environment and is actively involved in construction projects executed in this environment on a daily basis. As this is a subjective method for data collection, it is not the primary method for data gathering. The researcher had used the questionnaire survey as basis for his observations.

**DATA ANALYSIS AND HYPOTHESES TESTING**

As seen in Table 1, the key research variables measured in order to test *Hypothesis* 1 and 2 are: construction project risk categories (measured by “Yes” “No” nominal type questions), Construction project risk exposure levels (measured by “Low”, “Medium”, ”High” interval rating scale) and average percentage contingency risk allowance (measured by “5-10”, 11-15”, “16-20”, “20<” interval and ratio rating scale). The variables were derived from the research questions 1 to 4 proposed. Research questions, 1 and 2, identified “construction project risks” as the variable to be measured between the two populations by nominal scale in the form of “Yes” and “No”. Welman C, Kruger F and Mitchell B (2005: 229) proposed the use of multiple statistical analysis techniques to analyze data for question 3, however chi-squares test of McNemar was the most appropriate method to test *Hypothesis* 1. To answer research question 4, rating scales was the most appropriate method for collecting data. The derived variable from research question 4 is the “risk exposure level” of each construction risk category within the two populations, which was ranked in terms of “Low”, “Medium” and “High”. Welman C, Kruger F and Mitchell B (2005: 230) proposed the use of various statistical analysis techniques for interval measured data, but for the purpose of testing *Hypothesis* 2 the chi-square test of homogeneity was used.

## RESEARCH RESULTS

### Answers to Research Questions 1 and 1:

Through an in-depth literature review conducted, secondary data were collected and determined that no definite theoretical risk categories exists, hence the need for standard risk categories was identified in order to meet the research objectives. Based on the secondary data obtained, risk categories were assumed which in turn answered research questions 1 and 2 (see section 2.2), adapted from Han S (2005:9).

### Answers to Research Question 3:

In order to answer research question 3, primary nominal data was collected through means of questionnaire surveys conducted where respondents were asked to state whether or not assumed risk categories were in fact risks for either construction projects executed within the petro-chemical environment, in RSA and/or risks for projects executed in general. The data collected was tested against *Hypothesis* 1. The above mentioned hypothesis was tested against the primary data collected, by statistical means, making use of the chi-square test of McNemar. $H_0$ could not be rejected (see Table 2) based on the test statistics calculated, thus it was deduced that from the primary sample data collected, with a 95% confidence level, that construction related project risks faced during execution of projects within the petro-chemical environment in RSA are similar to risks faced for projects executed in general which in turn answers research question 3.

### Answers to Research Question 4:

In order to answer research question 4, primary interval data was collected through means of questionnaire surveys conducted where respondents were asked to rank risk exposure levels of risk categories considered as risks for both construction projects executed within the petro-chemical environment, in RSA and/or for projects executed in general. The data collected was tested against *Hypothesis* 2. The hypothesis was tested against the primary data collected, by statistical means, making use of the chi-square test of homogeneity. $H_0$ was rejected (see Table 2) at a 5% level of significance. Thus it was deduced from the sample data, with a 95% confidence level that construction related risk levels for projects executed in the petro-chemical environment in RSA differ significantly from projects executed in general, thus $H_1$ holds true that construction related risks for projects executed in the petro-chemical environment in RSA are higher than projects executed in general, thus answering research question 4.

Further statistical analysis was conducted on sample data collected from the research questionnaire whereby the frequency for each scale, namely “Low”, “Medium” and “High” was given a numerical value: “Low” = 1, “Medium” = 2, and “High” = 3. By multiplying the allocated numerical values by the number of frequencies for each scale, a risk rating score was calculated for each risk category for both construction projects executed within the petro-chemical environment, in RSA and for projects executed in general. Figure 3 shows a graphical representation of the risk rating scores for each risk category. It is clear, from the sample data collected, that construction projects executed within the petro-chemical environment, in RSA achieved significantly higher risk rating scores when compared to construction projects executed in general. The median and mode calculated for both projects executed within the petro-chemical environment, in RSA (median 12.5% and mode 11-15%) and for projects executed in general (median 9.5% and mode 6-10%), further supports the findings from the chi-square test of homogeneity, to test *Hypothesis* 2, that projects executed within the petro-chemical environment are "riskier" than projects executed in general, in South Africa.

Table 2 summarizes the test results as well as the test statistics applied to test both *Hypothesis* 1 and 2.

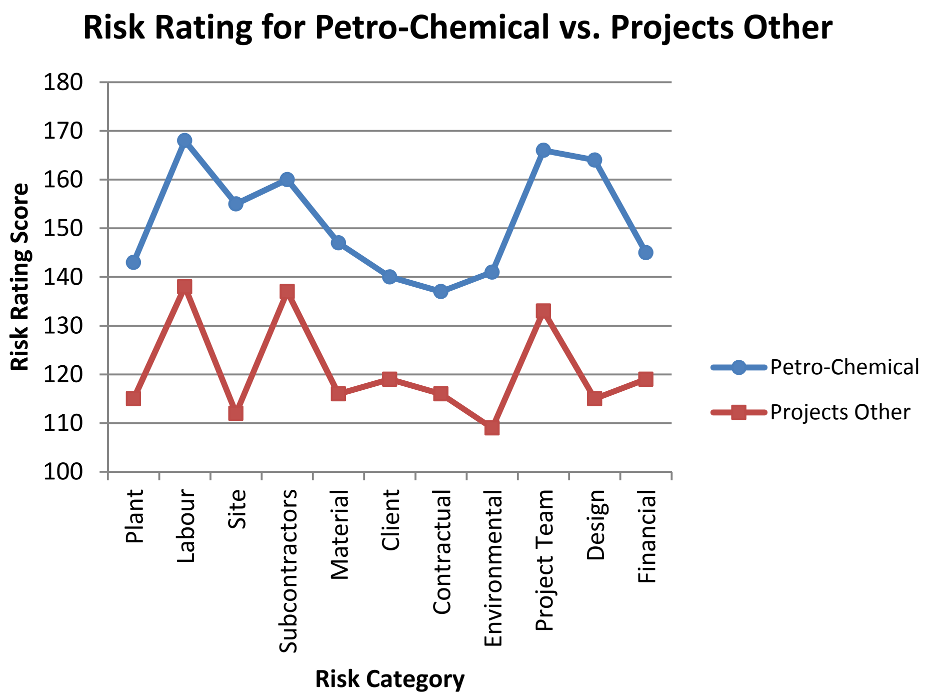


*Figure 3: Line diagram of risk rating scores for both petro-chemical and other projects*

<table>
<tr><th>Research Questions</th><th>Hypothesis</th><th>Significant Hypothesis test result?</th></tr>
<tr><td>Question 1: What construction related risks are faced within projects executed in the petro chemical industry in RSA?</td><td rowspan="3">Hypothesis 1: Construction related project risks faced during execution of projects within the petro-chemical environment in RSA are similar to risks faced for projects executed in general.</td><td rowspan="2">Typical Risk Categories assumed based on in-depth literature review</td></tr>
<tr><td>Question 2: What are the construction related risks faced, in general?</td></tr>
<tr><td>Question 3: Are there similarities in risks faced between construction projects executed in the petro-chemical environment and construction projects executed in general?</td><td>Yes (chi-square test of McNemar, since all critical values $m$ <3.841, $H_0$ cannot be rejected thus Hypothesis 1 holds true)</td></tr>
<tr><td rowspan="2">Question 4: Is construction projects executed in the petro-chemical environment in RSA, “riskier” than projects executed in general?</td><td rowspan="2">Hypothesis 2: Construction related risks for projects executed in the petro-chemical environment in RSA are higher than projects executed in general.</td><td>Yes (chi-square test of homogeneity, since all critical values c>9.488, $H_0$ can be rejected thus $H_1$ holds true thus Hypothesis 2 holds true)</td></tr>
<tr><td>No ( according to Steyn A, Smit C, Du Toit S and Strasheim C, (1994: 115) stated that grouped data set containing open-ended class intervals, it is impossible to calculate the arithmetic mean. As greatest interval that could be chosen was >20%, thus impossible to conduct a hypothesis test from the sample data collected)</td></tr>
</table>

*Table 2: Summary of hypotheses test results*

## CONCLUSIONS AND RECOMMENDATIONS

### Lessons Learnt from Literature Review:

As stated by Nicholas J, and Steyn H (2012:371), project management is risk management. Forward planning for projects is a form of risk management. Risk poses possible threats and opportunities to project outcomes. Risk is mostly associated with a “negative” impact, but identifying opportunities also forms part of the risk management process. Due to the characteristics of projects and risks, there is a lot of risk associated with projects in general due to their uniqueness. According to KPMG (2013:24), in the coming 20 years, the Integrated Resource Plan for Electricity 2010 – 2030, envisions reducing energy produced from coal from 90% to 65% and increase renewable energy sources to 9% (see section 1.2). As discussed during the introductory section, a survey conducted by Solidarity Research Institute (2010:3), indicated a shortage of engineers. The study conducted by Chihuri S and Pretorius L (2010:3), the authors had identified the inherent challenges faced within the South African construction industry, which relates to local sources of risk and which influences the industry. The power crisis and skills shortages are the major local risks faced within South Africa which has been highlighted by both KPMG as well as Solidarity. The following authors, Chihuri S and Pretorius L (2010:3), McGraw-Hill (2011:14), Visser K (2012), Chileshe N and Yirenkyi-Fianco A (2011:118), NEDO, London (2012), Nicholas J, and Steyn H (2012:353), Buerty J, Abeere-Inga E and Kumi T (2012:416), KPMG (2011:8), Baloy L and Bekker M (2011:55) and KPMG (2013:40) had identified typical sources of risks from various corners of the world from various construction project sectors, and from the research conducted, it is clear that no standard risk categories exist. The risk categories assumed for this study, could be applied to any construction type of project, as a mind-jogger and or a template, in order to identify the risks associated for construction projects during the risk management process. Akintoye A and Macleod M (1997:3) as well as Baccarini D (2004:1) stated that risks are associated with project costs and that when risk becomes reality, they transfer into monetary profit or loss. Various authors such as Smith P and Merrit G, (2002:19-25), Laryea S, Badu E and Dontwi I (2007:7) as well as Han S (2005:9-17), listed the typical risk management tools which can be applied to projects. A word of caution from the authors, Smith P and Merrit G, (2002:18), all models have a weakness as they represent only a partial reality. As there are a multitude of more complex models and risk management tools available in the market, they all share a similar disadvantage that "there is always something missing".

**Lessons Learnt from Hypotheses Test Results:**

*Hypothesis* 1 was tested and the hypothesis test result was significant and holds true that construction related project risks faced for projects executed within the petro-chemical environment are similar to risks faced for projects executed in general in South Africa. Thus the assumed risk categories identified can be applied over a wide range of projects as mind-joggers and or a template for identifying construction project risks in practice. *Hypothesis* 2 was tested and the hypothesis test result was significant and holds true that construction projects executed within the petro-chemical environment are more "riskier" than for projects executed in general in South Africa. This was further supported by descriptive statistical analysis whereby it was found that the average risk rating score, for all risk categories, for projects executed within the petro-chemical environment was 76.49%, thus 15.47% higher than for projects executed in general, with a score of 61.02%. As the contingency/risk allowance, from primary data collected, was calculated at a median of 12.5% and a mode of 11-15% for construction projects executed within the petro-chemical environment, a median of 9.5% and mode of 6-10% calculated for projects executed in general in South Africa, care should be taken by both clients and construction contractors entering and or tendering for projects within each one of these environments, as to ensure that sufficient contingency/risk allowance has been estimated in order to protect their set profit margins and to ensure meeting project goals and objectives. Clients and or contractors should allow for contingency/risk allowance of at least between 11-15%, for construction projects executed within the petro-chemical environment, and at least between 6-10% for construction projects executed in general, in South Africa.

**Recommendations**

It is recommended that for further research, that the sample population is increased, taking into account a total response rate of 35.2% and the active response rate of 57.04%, to improve on the sample size of n = 66, to reach the minimum required sample size of n = 136 for a quota or non-random self-selected sample. This will improve the generalizability of the findings from future similar studies. Secondly, the study can be conducted, in more detail, in order to differentiate between contracting and pricing strategies from both the client and construction contractor's perspective, whilst in the construction cost estimation phase of projects. Care should be taken to collect primary data from two separate groups, namely the client and construction contractor, seeing that risk allowances would differ significantly, Maritz M (2013)'s graphical representation illustrating the influence of both contracting and pricing strategies for both the employer and contractor on their allowed contingency/risk allowances allowed for on projects. A further study could be proposed whereby the assumed risk categories, identified earlier during this study, can be set as a theorem to be verified by means of hypothesis testing in order to be accepted as theory and in practice. In closing, a multitude of spin-off studies can be conducted, making use of this research as basis for further studies. Future studies conducted based on this research should be cautioned as risk management, is in its very essence, a managerial science, based on the human perception and tolerance for risk, and not based on hard facts as in pure scientific studies.

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