Priority analysis of pre-investment risks
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Abstract: Residential building construction projects are common to the local construction industry and they are almost always behind the schedule because of unforeseen risks. In the pre-investment phase, risks are high because of the uncertainty of the scope of works; therefore, a risk assessment report is even more important. This results in risks being scored incorrectly and some not being identified. The purpose of this research is to assist investors and other decision makers in identifying with specific risks in the pre-investment stage. Surveying of a sample population of construction professionals was carried out to determine the risk parameter scores based on a risk scoring matrix. The risk parameter scores were then prioritized in the order of highest to lowest risk impacts. Data analysis of the results was achieved by statistical tests. The results were then validated through case studies. This research finalized the priority of the risk parameters and identified that the major risk parameters are availability of direct labour, engineering designs, availability of materials, project scheduling and project management, respectively. Statistical tests confirmed that the specific differences between the dependent variables were cost and quality.

Keywords: building construction industry; cost; pre-investment; quality; risk parameters; risk priority; time

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PUBLIC INTEREST STATEMENT
Risk assessments in construction projects are nothing new to the industry. However, in the pre-investment stage of residential building projects, identification and mitigation of risks are difficult for potential investors. Because some of these investors may not have technical backgrounds or experience, there is enormous pressure on them to make the important decision of investing or not that early in a project. The repercussions of these risks, to investors, are cost, time and quality. This paper develops a set of risks identified and prioritized in order of importance that is associated with typical residential building projects to assist these investors. The results have been validated by case study.
1. Introduction

1.1. Background
The main phases of a construction project are the conceptualization/feasibility stage, planning/design stage, the construction/execution stage and the testing/commissioning stage. The phases previously described represent distinct levels of maturity and flexibility along to the project development. The level of maturity and flexibility is usually controlled by the degree of uncertainty, stakeholder involvement, and financial commitments regarding the project under analysis Carvajal and Arestegui (2014). As the project is realized more and more, the risk decreases. When more and better information become available and the project progresses into the project life cycle, nonetheless most of the critical decisions regarding project investment (go or not go) are made when uncertainty is still high, and limited information is available to provide good and sound basis for the decision-making process Carvajal and Arestegui (2014).

In relation to Latin America and the Caribbean, less attention is spent on the pre-investment phase of construction projects. Although research is limited to infrastructure projects, the findings were that the pre-investment phase of major infrastructure projects in Latin America and the Caribbean is often ill-structured. There are economic, political, anthropological, and social forces influencing it. The flawed pre-investment process in Latin America and the Caribbean is probably contributing to cost overruns and delays Alberti (2015). These are the main areas of risk identified, cost, time and quality. There is room for feasible policy improvements in the pre-investment phase in Latin America and the Caribbean that would enhance infrastructure delivery, boost growth, and promote development in the region. This aims at capturing an accurate risk assessment document that can help achieve this.

Based on this background, this research is based on surveying of a sample population followed by data analysis to determine pre-investment risk priorities of residential buildings in Trinidad and Tobago. Specific to local residential buildings, the Beverly Hills housing project at the outskirts of Port of Spain had time overruns of 400% and cost overruns of 100%. This was due to the project being located in an area where there was a high risk of crime Uff and Thornhill (2010), which was not taken into account in the pre-investment stage. At Blenheim housing project, Tobago, the project experienced time overruns of 200% and cost overruns of 40% caused mainly by the risk failure of planners to consider steep topography of the site Uff and Thornhill (2010).

1.2. Literature review
Clients are often faced with the hard task of making a hurried uninformed decision of whether to invest or not. Because of this, they are exposed to unforeseen risks, sometimes catastrophic to the project. Risk parameters can be analysed, but one must identify the risk parameters using literature reviews and conduct surveys with clients. It was concluded that many risks arise in the earlier project stages by Tsai and Min-Lan (2010). Having a set of risk priorities in an industry, such as construction, where there are high levels of uncertainty is critical for success. Aboushady, Ahmed et al. (2013) proposed a set of risk priorities for design, financial, construction, legal and regulation. However, this was not specific to pre-investment residential building projects. In a forum for the Construction Lender Risk Management Roundtable, Ward (2014) highlighted that Coming out of this, they identified risks to include inadequate engineering plans, change orders to correct errors not identified early on, use of construction materials different from those originally specified, inexperienced contractors making costly errors, and so on. He argued that in his experience, the most common mistakes are inadequate analysis of the proposed budget and insufficient time allotted for construction and lease-up or sell-out.

The Uff report, as coined locally, highlighted the fact that malpractices and bad methods were being used in the local construction industry. The main arguments put forward by Uff and Thornhill (2010)
dealt with the types of procurement methods being used and general construction project management issues. Specific to this research are the risks highlighted for the issues of cost over-runs, delays and defects. Some of the risks highlighted in the report were availability of resources, site selection, procurement methods, engineering designs, planning, weather, obsolescence, weather, life cycle costs and general project management. They concluded that improvements to all the risks highlighted are needed to ensure project success. Rezakhani (2012) highlighted the importance of using a hierarchical risk breakdown to capture all risks involved in typical construction projects. This is applicable for regular and complex projects. Some of the risk considerations will be used for this research.

Lingard et al. (2014) explored the relationship between the timing with which decisions are made about how to control risks in construction projects (i.e. either pre- or post-construction) and the quality of risk control outcomes. They deduced that the earlier that risks are identified, the better they are mitigated. The results also reveal a significant relationship between the quality of risk controls and the timing of risk control selection decisions. The greater the proportion of risk controls selected during the pre-construction stages of a project, the better the risk control outcomes. This justifies the need for a specific list of risks prioritized in the pre-investment stage of construction projects locally. Another aspect of the risk priorities is those associated with cost. Carvajal and Arestegui (2014) highlighted this in his research as he contended that cost will firstly influence the decision-making process in the execution phase and during project appraisals. To avoid this, the risk parameters can, as mentioned earlier, be identified earlier in the pre-investment stage where it is still fair to the investor to commit his money or not.

The pre-investment stage is important to this regard and, as researched by Alberti (2015), it is even more pronounced in Latin America and the Caribbean. Projects were found to be ill-structured and influenced by a number of external factors. The analysis concludes that a flawed pre-investment process in Latin America and the Caribbean is probably contributing to cost overruns and delays. These are the main areas of risk prioritization identified, cost and time. Like the author before, Gransow (2015) also focused on Latin America and the Caribbean. He deduced that based on the risks associated with pre-investment risks in the region, the Inter-American Development Bank and the World Bank direct more than a third of their loans to other sectors like health, social etc. One of the key stumbling blocks identified is that investors, entrepreneurs, banks and borrowers focus predominately on the financial and economic risks, and engineers look mainly at the technical risk parameters. These considerations will be made in this research. Jimoh et al. (2016) conducted research on the pre-construction and construction risks on active project sites in Nigeria. He found that the main risk parameters identified between the two phases were “errors and omissions in design” and “improperly defined project scope.” It was recommended that procurement methods such as construction management should be adopted and stakeholders should keep to their own side of the bargain to avoid unnecessary delays. The following Table 1 shows the risk considerations used by the key players.

1.3. Significance of the research
Research has been carried out, separately, on all of the scenarios identified in the above Table 1 in one part or the other by the authors. But, in this literature review, no systematic research has been found that encompasses specific considerations of the pre-investment phase, residential building construction, risk priority analysis and applicability to Trinidad and Tobago. Therefore, this research is based on the prioritizing of pre-investment risks in residential building construction projects, using data analysis. Although the current study is based in Trinidad and Tobago, the research has information that can provide preliminary guidelines for the other Caribbean Small Island Developing States (SIDS) due to the social, economic and climate similarities. The research will be based on a structured questionnaire survey of a specific population deemed to have the proper blend of risk qualifications and experience.
1.4. Research question
How are the impacts of the pre-investment risk parameters, with regards to cost, time and quality, assessed on typical residential building projects, and what are the order of those impacts?

1.5. Aim and objectives
The aim of this research is to improve project success in the pre-investment phase of residential building projects through risk priority analysis.

The objectives are:

(1) To identify the prevalent risk parameters in the pre-investment phase of typical residential building projects in Trinidad and Tobago.

(2) To assess the impact of the pre-investment phase risk parameters through data analysis and determine the dominant risk parameters with respect to cost, time and quality.

(3) To evaluate the order of priority of the pre-investment risk parameters based upon impact analysis.

1.6. Scope
The scope of this research is defined by the objectives, as listed above. Identifying the prevalent risk parameters in the pre-investment stage of residential projects locally can be an exhaustive exercise. However, some main risks are site selection, procurement methods, engineering designs, planning and general project management Uff and Thornhill (2010). Other risks include engineering plans, change orders to correct errors not identified early on, use of construction materials different from those originally specified and use of inexperienced contractors making costly errors Ward (2014). These risk parameters, along with others obtained from the literature review will comprise the risks being identified to conduct the research. Assessing the risk impacts is another task to be achieved. To properly assess this it must, firstly, be identified what exactly the risk

| Item | Risks | (Aboushady, Ahmed et al., 2013) | (Rezakhani, 2012) | (Ward, 2014) | (Uff & Thornhill, 2010) |
|------|-------|-------------------------------|-------------------|--------------|--------------------------|
| 1 | Project Management | ✓ | ✓ | ✓ | ✓ |
| 2 | Engineering Designs | ✓ | ✓ | ✓ | ✓ |
| 3 | Procurement Route | ✓ | ✓ | ✓ | ✓ |
| 4 | Lack of Insurances | ✓ | ✓ | ✓ | ✓ |
| 5 | Project Scheduling | ✓ | ✓ | ✓ | ✓ |
| 6 | Availability of Direct Labour | ✓ | ✓ | ✓ | ✓ |
| 7 | Availability of Materials | ✓ | ✓ | ✓ | ✓ |
| 8 | Availability of Equipment | ✓ | ✓ | ✓ | ✓ |
| 9 | Obsolescence | ✓ | ✓ | ✓ | ✓ |
| 10 | Life Cycle Costing | ✓ | ✓ | ✓ | ✓ |
| 11 | Sustainability | ✓ | ✓ | ✓ | ✓ |
| 12 | Weather | ✓ | ✓ | ✓ | ✓ |
| 13 | Inflation | ✓ | ✓ | ✓ | ✓ |
| 14 | Availability of Foreign Exchange | ✓ | ✓ | ✓ | ✓ |
| 15 | Achieving the desired Profit Margin | ✓ | ✓ | ✓ | ✓ |
parameters influence. Managing risk parameters in construction projects has been acknowledged as a key direction process for the purposes of attaining the project goal in terms of cost, time & quality Jimoh et al. (2016). Therefore, the analysis of the risk impacts will be based on the different risk dependents mentioned earlier; cost, time and quality. Surveying of a sample population and data analysis will be used. Data collection was restricted to all construction professionals deemed to have the adequate blend of qualifications and experience in relation to pre-investment risk analysis. This was not limited to any specific profession in the construction industry. The results from the data analysis will then be evaluated and it will be compared to five case studies carried out for validation.

2. Methodology
The target population is experienced professionals who are comprised of stakeholders, architects, engineers, project managers, quantity surveyors, investors and anyone else deemed to have had experience in dealing with risks in the pre-investment phase of a residential building construction project. The data were sorted and analysed to derive findings and conclusions as per the research design model in Figure 1. The research is a constructivist idea as data are already available in a qualitative format, the risk analysis. It is a non-parametric study with independent and dependent variables. The independent variables are the risk parameters and the dependent variable will cost, time and quality. This will make the research more deductive. Ethical considerations are made and no classified information will be used.

2.1. Questionnaire design
The survey questionnaire is designed to achieve the objectives of the research and ultimately provide a framework to answer the research question. There are a total of 28 questions in which 11 questions in section one and 17 questions in section two.

A pilot study was carried out before the actual survey. The pilot survey study was done with 10 individuals being used as a trial. People interviewed were randomly selected and was not part of the actual survey, to avoid biasness. The aim of the pilot study, specific to this research, was to ascertain if the data received can be used for data analysis. Sensitive questions about personal and private information were avoided, partly to do with preventing participants from presenting false data and also to keep all participants anonymous. The questions were therefore based on a general professional basis. Feedback was based on the length of the survey, the relevance, the satisfaction level people had with contributing to the survey, the user-friendliness, the type of industry professionals deemed to be expert judges of the survey topic with risks who could contribute to the study, the delivery method of the survey, and ensuring validity to the process. This feedback was then used to refine the survey into a more efficient version.

Figure 1. Research Design Model.
Section one of the questionnaire is made up of a mixture of open- and closed-ended questions that are designed to generate general information about the respondents.

Section two is made up of closed-ended questions specific to the research and provides checkboxes for cost, time and quality considerations where applicable for each risk. The checkboxes for the cost, time and quality considerations were broken up into severity and likelihood scenarios. Every respondent were required to select a severity and likelihood scenario for each consideration for all of the risk parameters.

Further to the research design model, the objectives are also achieved specifically through the questionnaire as follows:

Objective 1—This objective is achieved primarily through the literature review. However, questions 16 and 17 in section two of the survey questionnaire are designed to capture any legitimate risks that should be considered.

Objective 2—This objective is achieved through questions 1 to 15 in section two of the survey questionnaire. Each risk was assessed with time, cost and quality considerations. The average was then calculated to achieve the overall risk rating. This was done to achieve an accurate risk assessment from the respondents and determine the dominant risk attitude.

Objective 3—Questions 1 to 11 in section one of the survey questionnaire were used to achieve this. Questions in this section were also used as the key points in the discussion to analyse the validity of the risk priorities.

2.2. Sampling size
The sample size is an important consideration. The Kish Equation (Kish, 1965) was used because of the small sample population size. The formula is \( n = \frac{(n^1)}{(1 + (n^1/N))} \).

where

\( n^1 \) = measured sample size from finite population

\( N \) = total population

\( n^1 \) = a sample size from an infinite population = \( s^2/v^2 \)

\( s^2 \) = variance of the population

\( v^2 \) = standard error

Now substitute the following values:

\( N = 500, s = 0.5 \) (A variance of 50% was selected so as to account for maximum variance possible) and \( v = .06 \)

The sample size is calculated as follows:

\( n^1 = \frac{s^2/v^2}{(.06)} = 69.44; \text{ therefore, } n = \frac{(69.44)}{(1 + (69.44/500))} = 61 \)

For the purpose of this survey, and additional 7 respondents were added to the recommended sample size. Therefore, the sample size for this research is 68 persons.
A total of 122 surveys were administered to professionals. Twelve to the top members of the Trinidad and Tobago Institute of Architects (TTIA), 60 to the top members of the Association of Professional Engineers in Trinidad and Tobago (APETT), 25 to the top members of the Trinidad and Tobago Contractors Association (TTCA) and 25 to members of the Ministry of Housing (MOH). The response rates were in the range of 33% to 63%, and the average response rate was 50%. This is an accepted response rate as demonstrated by Yakubu and Ming (2015) whose similar surveys were on average 27% response rate. The response rates can be seen in Table 2, below. The information generated from the survey was used for discussions and deriving answers for the research questions and conclusions.

2.3. Risk scoring
The risk parameters, as presented above, are prioritized initially in ascending order of importance. This is subject to be revised upon new findings in the research. The risk ranking is based on a numerical matrix as recommended by the International Organization for Standardization (ISO 9001: 2015). There is no one specific format for the matrix, instead it is drawn up to suit the specific needs of the organization. The matrix, for this research as seen in Table 3, compares the likelihood and the severity of the risks and ranks them accordingly.

Each risk score is calculated by multiplying the two axis of the matrix, which is:

\[ \text{Risk Scoring} = \text{Severity} \times \text{Likelihood} \]

Based on the number calculated, the risks are then categorised into a risk percentage bracket. In order to gain a true and unbiased scoring of the risk parameters in the survey, each one was broken up into cost, time and quality combinations where applicable to each risk. The median of these scores will then be used to determine the prioritization of the risks. The higher the scores the greater the threat. This risk scoring matrix will be used in the preparation of the survey questionnaire to categorize and ultimately prioritize the risks.

2.4. Statistical analysis of results
The survey data obtained from the questionnaire will be analysed using the following statistical tests to determine relevant findings and achieve the objectives of the research. Because the population data in this research does not have a normal distribution, the non-parametric tests will be used. Tests will be carried out on the risk parameters in Table 1 comparing the cost, time and quality variables for each where applicable. The non-parametric tests applicable to this research and their respective criteria are:

(a). 1 sample sign test—The 1 sample sign test determines whether the hypothesized value is greater or lesser than the sample median, these values will be determined when analysing the survey data. The general hypothesis for the test is:

\[ H_0: \text{The probability distributions are the same.} \]

| Institute/Ministry | Surveys Issued | Respondents | Response Rate |
|--------------------|---------------|-------------|---------------|
| TTIA               | 12            | 4           | 33%           |
| APETT              | 60            | 38          | 63%           |
| TTCA               | 25            | 12          | 48%           |
| MOH                | 25            | 14          | 56%           |
| **Total Respondents** | **68**     |             |               |
The probability distributions are not the same. 

More specific, to the research, the test will be carried out to determine if:

\[ H_0: \text{cost} = \text{time} = \text{quality} \]

\[ H_1: \text{cost} \neq \text{time} \neq \text{quality} \]

One limitation of this test however is that, if there is any association, it cannot calculate the strength of the association or where the association may be. Further testing will be needed to verify the results of this test.

The overall median risk scores for the cost, time and quality considerations will be used, in the test, for each risk parameter. This test is applicable to all of the 15 risk parameters and one test will be carried out. The purpose of this test is to simply determine if the probability distributions for the variables of cost, time and quality are the same or not with respect to the risk parameters. The alpha value to be used will be 0.05, this is a confidence level of 95%.

(b). Chi-square test of independence—This will be used to further test if there is an association between cost, time and quality considerations of the risk parameters. However, unlike using the overall median values of the 1 sample sign test above, it will be broken down into each consideration and analysed. Therefore, the individual median values for cost, time and quality will be used. Again, the general hypothesis for the Chi-square test of independence will be expressed as follows:

\[ H_0: \text{The three probability distributions are the same.} \]

\[ H_1: \text{The three probability distributions are not the same.} \]

Again, the test will be carried out on all runs of the Chi-square test to determine if:

\[ H_0: \text{cost} = \text{time} = \text{quality} \]

\[ H_1: \text{cost} \neq \text{time} \neq \text{quality} \]
The alpha value for all the tests will be 0.05 and the test is two-tailed. Three runs of the Chi-square test will be carried out to reject or fail to reject the null hypothesis.

The first run will be done by comparing the variables of cost, time and quality median values for all 15 risk parameters where applicable. This will give a result of the hypothesis for the overall data spread in the research. However, this result will be based on the entire data spread, this may not be a true reflection of the results. Therefore, the next two runs will be done using a smaller data spread of selected risk parameters based on their data results. More so the second test will be done by comparing six selected risk parameters, the three with the highest scores and the three with the second highest scores. The third and last test will be done by comparing another six selected risk parameters, the three from the second highest scoring group and the three from the rest of the field in the lowest region. Again, using the variables of cost, time and quality median values for risk parameters will be used where applicable.

It is expected that the results will be obtained to execute these specific test runs of the Chi-square test. Each test will be carried out on the same hypothesis as stated above. The limitation of this test is that it also cannot calculate the strength of the association, if any is found. One further test will be done to determine if there are any associations.

(c). Wilcoxon signed-rank test—This test will be used to further break down the data and analyse it. This time the median values for the dependent variable median samples will be analysed in three pairs. The three pairs to be analysed are cost and time, cost and quality and time and quality. This will determine exactly where the associations are among the dependent variables, if any. The general hypothesis will again be:

\[ H_0: \text{The three probability distributions are the same.} \]
\[ H_1: \text{The three probability distributions are not the same} \]

This time, specific to the research, all three runs will be carried out to determine:

1st Run: \( H_0: \text{cost} = \text{time} \)  
2nd Run: \( H_0: \text{cost} = \text{quality} \)  
3rd Run: \( H_0: \text{time} = \text{quality} \)

\[ H_1: \text{cost} \neq \text{time} \]  
\[ H_1: \text{cost} \neq \text{quality} \]  
\[ H_1: \text{time} \neq \text{quality} \]

This will further determine the strength of the associations. The alpha value will be 0.05, this is a confidence level of 95%. This is a two tailed test.

3. Analysis and discussion

3.1. Objective 1
This objective was achieved in the literature review, as seen in Table 1 earlier above.

3.2. Objective 2

3.2.1. The influence of the risk parameters on cost, time and quality
Cost, time and quality were influenced differently by the risk parameters. As seen in Table 4, cost was influenced most by the risk parameters, then time and lastly quality. The highest median values of cost, time and quality for the risk parameters represented the opinions of the sample population in this table. The table illustrates the median scores obtained for the survey
questionnaire and the percentage, calculated with the median score divided by the maximum score of 25 multiplied by 100.

Fourteen out of the 15 risk parameters, with the exception of availability of direct labour, had high influences over cost. This illustrates that cost is an ever present dependent on the decision-making process in the pre-investment phase Boz and Mendoza (2010). The omission of labour is surprising as this is one of the most difficult resource to manage. Labour wages are always a source of dispute when it comes to production. From local industry experience, the general rule of thumb is that labour accounts for approximately 40% of a typical construction rate build-up. It was found that respondents only narrowly scored the cost consideration for labour, with a median of 15.5, lower than time and quality which they scored 16. Therefore, it cannot be significantly ignored as a high influence over cost. When all of the risk parameters were evaluated to assess the prioritization of the risks with cost considerations. The results revealed that 33% of the risk parameters were above 62%, whereas the others were below 48%. This identified a cluster of high risk scores. The high risk parameters were project management, engineering designs, project scheduling, availability of materials and availability of direct labour, respectively. All of them were scored between 62% and 64% risk threat. None of these risk parameters are surprising. As discussed in the literature review, cost is seen as the most important link in the iron triangle of cost, time and quality. It is not surprising that cost will be the most dependent on the risk parameters.

The time consideration was less dominant. Nine out of the 11 applicable risk parameters had high influences over time. The exceptions were engineering designs and obsolescence. The other four risk parameters omitted were profit margin, life cycle costing, lack of insurances and sustainability as they were deemed not applicable for analysis with time considerations. Engineering designs were surprisingly not a high influence. It is often found that more time spent in the planning and design stage guarantees a greater chance of project success Carvajal and Arestegui (2014). Therefore, this risk parameter should have influenced the time consideration more. However, further analysis of the survey results revealed it was much closer than this. It was found that engineering designs scored a higher risk threat of median 16 for cost and quality parameters.

| Rank | Risk Parameters* | Cost % | Time % | Quality % |
|------|------------------|--------|--------|-----------|
| 1    | Availability of Direct Labour | 16     | 64     | 16        |
| 2    | Engineering Designs | 16     | 64     | 16        |
| 3    | Availability of Materials | 16     | 64     | 16        |
| 4    | Project Scheduling | 16     | 64     | 16        |
| 5    | Project Management | 16     | 64     | 16        |
| 6    | Weather | 12     | 48     | 12        |
| 7    | Procurement Route | 12     | 48     | 12        |
| 8    | Obsolescence | 12     | 48     | 12        |
| 9    | Inflation | 12     | 48     | 12        |
| 10   | Foreign Exchange | 12     | 48     | 12        |
| 11   | Availability of Equipment | 12     | 48     | 12        |
| 12   | Profit Margin | 12     | 48     |           |
| 13   | Life Cycle Costing | 12     | 48     |           |
| 14   | Lack of Insurances | 12     | 48     |           |
| 15   | Sustainability | 9      | 36     |           |

*Each risk parameter can influence more than one variable with the highest median score.
considerations. For time considerations it achieved a slightly lower median of 15. The severity and likelihood of this risk parameter were ranked almost identical for cost, time and quality. Therefore, it cannot be significantly ignored as a high influence over time.

When the time consideration was evaluated to assess the prioritization of the risks, the results again revealed a cluster of high scores. With project management, project scheduling, availability of direct labour, availability of materials and engineering designs, respectively, between 60% and 64%. And similar to cost, the others were below 48%. These were the same risk parameters that featured in the cost considerations top five as well. This indicates that a similar approach to cost and time were used by the respondents during the surveying exercise.

With regards to the quality consideration, five out of the 10 applicable risk parameters were high influences over time as per Table 4. With the other five risk parameters of availability of materials, project management, project scheduling, life cycle costing and profit margin being the exceptions. Project management was surprisingly not a high influence. When analysed in the survey results, it was found that respondents scored time and cost with median 16 scores compared to a much lower 12 for quality. Therefore, based on the survey results, project management cannot be viewed as a high influence over quality. Engineering designs and availability of direct labour both featured on cost, time and quality considerations for prioritization of risks tables. With project management, project scheduling and availability of materials all featuring on the cost and time considerations for prioritization of risks tables. 

It can therefore be deduced that these are the five risk parameters that have a major influence on cost, time and quality considerations. This can also be seen in Table 4 where they are clustered together based on the overall prioritization of the risks. The other risk parameters have a lesser influence on the risk considerations. To further analyse the impacts of this influence, statistical testing was done to determine the associations of the probability distributions between the dependent variables.

3.2.2. The statistical analysis of the dependent variables cost, time and quality
The three statistical tests carried out to determine the associations between the probability distributions of cost, time and quality reported contrasting results. Firstly, the 1 sample sign test was done, as seen below in Table 5, and it rejected the null hypothesis that cost, time and quality are equal to each other. Therefore, it reported that the three probability distributions were different.

This was somewhat surprising as these variables are thought to be dependent on each other as well as the risk parameters. Although this test was done, like all of the others, at a 95% confidence level it still cannot determine the specific differences. This is partly because that the overall median score was used in this test.

Secondly, to further refine the results, the Chi-square independence test was done and this further rejected the null hypothesis that cost, time and quality are equal to each other. This was also a surprising result as the test was done analysing the cost, time and quality medians separately after three runs of the tests were carried out. The 1st run testing all of the 15 risk parameters. The 2nd run testing project management, engineering designs, project scheduling, availability of equipment, weather and inflation. And the 3rd testing lack of insurances, availability of equipment, life cycle costing, weather, inflation and profit margin. Some overlapping of the risk parameters were maintained in each run. The results can be seen in Table 6.

Thirdly, the Wilcoxon signed-rank test was carried out to further refine the results as this test is considered an alternative to the T-test for non-parametric data. This test revealed the most interesting results as it rejected the null hypothesis for cost and quality reporting a difference in the probability distributions for both. However, it accepted null hypothesis for cost and time
combinations as well as time and quality considerations. Because the null hypothesis was rejected in cost and quality scenario only. The results can be seen in Table 7 below.

The disassociation of cost and quality can be attributed in part to the method of the sample survey population completing of the survey questionnaire. It is possible that respondents did not fully interpret the questions posed, perhaps they didn’t take the proper time to think due to multi-tasking or it may be even due to a lack of interest in the research topic.

It was not surprising that cost and time were found to have an association Uff and Thornhill (2010). This is further validated by the common phrase “time is money”. Locally, these can be seen as the more important variables than quality. An example of this is the Uff report where analysis was done on the local construction industry. Although quality was included in the report, the

| Table 5. Sample sign test results |
|----------------------------------|
| Hypothesised Median              | 10  |
| Actual Median                    | 12  |
| No. Positive Signs               | 13  |
| No. Negative Signs               | 2   |
| Total Count                      | 15  |
| Smaller value                    | 2   |
| Calculated p value               | 0.004 |
| Alpha Value                      | 0.05 |

RESULT: p value is smaller than Alpha value, therefore we reject the null hypothesis.

| Table 6. Chi square test results |
|----------------------------------|
| 1st Run (cost, time and quality) | 2nd Run (cost, time and quality) | 3rd Run (cost, time and quality) |
| Alpha Value                      | 0.05 | 0.05 | 0.05 |
| Degrees of Freedom               | 28   | 10   | 10   |
| Critical Value from Table        | 41.34 | 18.307 | 18.307 |
| Calculated Chi Square Value      | 85.36 | 20.156 | 53.203 |
| RESULTS                          | Reject Null Hypothesis | Reject Null Hypothesis | Reject Null Hypothesis |

| Table 7. Wilcoxon signed-rank test |
|------------------------------------|
| 1st Run (cost and time)           | 2nd Run (cost and quality) | 3rd Run (time and quality) |
| Alpha Value                       | 0.05 | 0.05 | 0.05 |
| T -                               | 75   | 105  | 79.5 |
| T +                               | 45   | 15   | 40.5 |
| N                                 | 15   | 15   | 15   |
| W Stat calculated                 | 45   | 15   | 40.5 |
| W Critical from Table             | 25   | 25   | 25   |
| RESULTS                           | Fail to Reject Null Hypothesis | Reject Null Hypothesis | Fail to Reject Null Hypothesis |
majority focused on cost and time. Therefore, it was natural for the respondents to score cost and time similarly and view quality as somewhat of a lesser risk. Theoretically, this should not be the case with an educated and experienced bunch of professionals, but it is here. From past research, it can be deduced that risk management may not be used effectively Serpell et al. (2017).

Another reason for this may be that quality is the most complex of all the variables to score. For cost and time, we have bills of quantities and project schedules, respectively, which are numerical based. Therefore, they are easy to interpret, monitor and report on. Because they are understood more by the construction professional, it is easier to score them in risk assessments as opposed to quality. Obviously, this may not be the case for all of the respondents, but based on the results of this research, this can be deduced.

Ironically, time and quality were identified to have the same probability distributions. This shows that cost is the variable with the different probability distribution.

In this research cost is also the main dependent variable on the risk parameters as seen in Table 4. This may be so because everything in construction depends on money. Time delays may be absorbed in the project schedule and not affect the overall completion date. But once monies are spent this affects the overall savings on the budget, whether it was accounted for or not. It is clear to see why the sample survey population would rank the cost consideration of the risk parameters the most risky ones.

3.3. Objective 3

3.3.1. Risk prioritization
A close inspection prioritization of the risks showed that the results that were anticipated as the technical issues got higher ratings as compared to the economic, financial and environmental issues in Table 8 next page.

The table, above, prioritized the risks based on their median scores from the questionnaire survey of the sample population. The risk prioritization was achieved with the median score divided by the maximum score of 25 multiplied by 100. The percentage is important as it represents the level of priority the risk parameters have in the pre-investment stage. According to Alberti (2015), the pre-investment phase of major infrastructure projects in Latin America and the Caribbean is often ill-structured, as it is interdisciplinary—that is, there are economic, political, anthropological, and social

| Rank | Risk Parameters             | Median Risk Score | Risk % |
|------|-----------------------------|-------------------|-------|
| 1    | Availability of Direct Labour | 16                | 64%   |
| 2    | Engineering Designs         | 16                | 64%   |
| 3    | Availability of Materials   | 16                | 64%   |
| 4    | Project Scheduling          | 16                | 64%   |
| 5    | Project Management          | 16                | 64%   |
| 6    | Weather                     | 12                | 48%   |
| 7    | Procurement Route           | 12                | 48%   |
| 8    | Obsolescence                | 12                | 48%   |
| 9    | Inflation                   | 12                | 48%   |
| 10   | Foreign Exchange            | 12                | 48%   |
| 11   | Availability of Equipment   | 12                | 48%   |
| 12   | Profit Margin               | 11.25              | 5%    |
| 13   | Life Cycle Costing          | 11.25              | 45%   |
| 14   | Lack of Insurances          | 10.50              | 42%   |
| 15   | Sustainability              | 9                 | 36%   |
forces influencing it. This research was designed to focus on the technical risks and stay away from
the political, anthropological, and social issues. From the findings it can be seen that the top five risk
parameters whose scores of 64% each were all technical risks. There is a significant gap of 16%
between the next highest risk scores groupings of 48%. This shows that out of the 15 risk parameters,
the top five are the most significant ones.

As seen earlier, they consistently feature in cost, time and quality prioritization tables. One of the
significant risks in project realization is the increase of total cost. A large number of investment
projects were forced to suspend construction due to cost deviation from the planned cost
Baumgertel et al. (2016).

Based on this, it is not surprising to see that 14 of the 15 risk parameters as per Table 4 are
influences to cost. This is further confirmed by case studies done by researchers, as 41% of the
losses of construction projects are related to miscalculations in the pre-contract phase and 22% to
project risks. Thirty per cent of the costs incur during the construction phase and only 7% is related
to force majeure. Claudius et al. (2015). In order to reduce the risk of cost via these risk para-
meters, accurate pre-investment risk assessments are significant to project success. In this
research, cost is influenced by 93% of the risk parameters. Whereas time is influenced by 60% and
quality is influenced by 33%. This clearly shows that the sample population's bias is towards
cost-related decision-making.

On the other side of the coin however, the lowest ranked risk parameter was sustainability with
a 36% risk score. This is not surprising as this concept has not gotten much consideration, to date,
in the local construction industry. It should be noted that public sector companies, mainly some of
the special purpose companies, do consider it as an important factor. Equally surprising was the
lack of insurances second to lowest risk rating score of 42%. Insurances are a general requirement
on all investment projects. This can be explained as, discussed earlier, 53% of the sample popula-
tion were from the private sector where business transactions and requirements are not as
stringent and bureaucratic as the public sector. Another reason may be that private sector
businesses use cash more that public sector businesses. Weather was ranked in the second
grouping of 48%. This was surprising as, historically, weather has not significantly affected the
performance of local construction projects. Although it has been cited in the Uff report to be a risk
factor for time delays on residential projects locally. However, with only rainy seasons and dry
seasons to contend with, construction schedules and costs are not overly affected by the rains.

One explanation for the fact that the overall priority of the risks changed up is that there are
differences between the dependent variables of cost, time and quality. The Chi-square test
significantly rejected the null hypothesis, at a 95% confidence level, that the probability distribu-
tions are the same.

3.3.2. Risk score percentage impacts
The difference between the highest risk score percentage and the lowest is 28% as seen in Table 8
. This is significant as it shows that the risks were ranked in groups with deviations. The overall
highest risk score percentage was 64% which was scored for the first five risk parameters. The
highest scored risk parameter was labour. The lowest scored risk parameter was sustainability with
a score of 36%. All the other risks fall into this category between 36% and 64%. This means that all
of the risk parameters were scored between the 1/3% and 2/3% range of risk threats.

The median risk score percentage was 48%. In order to achieve this, a score of 12 out of 25
would have to be gotten. This means that a calculation of (3*4) would need to be done with the
severity and likelihood assuming either one of the numbers. The likelihood and severity scores
were very similar throughout the survey. They were identical for the top five risk parameters with
both likelihood and severity achieving median scores of four. The highest rating of 64% means that
the calculation was (4*4), and the lowest rating of 36% means the calculation was (3*3). This
shows that the respondents rarely differed in their scoring of the likelihood and severity between three and four. There were cases of recorded scores of one, two and five also, for both likelihood and severity, but these did not affect the median much as the majority of the scores were between three and four. The median scores were also 12 for the cost, time and quality considerations when analysed separately as well. This shows that the risk parameters were all scored in the same manner for the different considerations.

One reason for this may be the interpretation of the likelihood and severity scenarios. It is possible to assume that, based on the scores mentioned above, the respondents rated the two scenarios the same. This may be as a result of persons not perusing the survey and taking the proper time to study the responses, all in an attempt to complete it quickly. Another reason may be that the practical application of the risk management tools, especially by project managers, are poorly utilized. Jepson et al. (2018) found that these current tools do not reflect the current project manager practice.

Risk scoring, as deduced from the literature review, is highly subjective. This highlights the importance of selecting the correct sample population to survey. The respondents scored the risk parameters in a conservative manner but utilizing the middle categories. This approach ensured that there were not much high or low scores to significantly skew the data. To further eliminate the skewing of the data, the median was used to determine the score. This score in turn was used to determine the percentages out of a maximum of 25.

3.3.3. The international approach to risk assessment in the pre-investment stage

Researchers have discovered that the earlier risks are discovered and mitigated the greater the chance for project success. This is a resounding tone for this research paper as well. Case studies have proven this point. One such study carried in Australia and the United States of America by Lingard et al. (2014) revealed a significant gap with first world countries as compared to local standards. The results indicate that “risk control outcomes were significantly better in the Australian compared with the US cases. The results also reveal a significant relationship between the quality of risk controls and the timing of risk control selection decisions. The greater the proportion of risk controls selected during the pre-construction stages of a project, the better the risk control outcomes. This is as a result because in Australia, for example, legislation requiring designers of buildings and structures to consider risks in their decision-making has been implemented in all jurisdictions. While not a statutory requirement in the USA, “Prevention through Design” has been the focus of a number of industry reports and initiatives. Apart from Australia and the United States of America, China, as seen above, has also realized the importance of risk assessment earlier on in construction projects. According to the Mills (2016) on a B1 M report, both China and the United States of America are projected to have the top two construction industries in the world by 2030. It is estimated that by then the construction industry will account for 14.7% of all global economic output. The United Kingdom is fifth on the list. This is important as our construction industry is heavily influenced by British theories and qualifications.

It is unrealistic to think that the Caribbean can be on top of that list. One reason for this is the sheer differences in the population of the countries, which dictates the need for construction. However, if the methods used by the biggest construction countries in the world can ensure project success then it should be done, with specific regards to pre-investment risk assessment in the residential building construction projects.

This can only be beneficial to our construction industry. One way will be by saving tax payers monies and not hiring foreign consultants for reports on our construction industry debacles. They simply recommend the successful strategies that are implemented in their own countries and charge a substantial fee for their services. One example of this is the Uff report in 2010. It can be seen from case studies that regulatory laws for risk assessments are needed to ensure that less risks arise later on that can cripple or even halt construction projects. The pre-investment stage is the earliest stage that this can happen. There is a template by the first world countries that can be modified and used to
minimize risks in residential building construction projects. This has to be done in the pre-investment stage of the project. Iqbal et al. (2015) cited that adherence to proper schedules in the implementation stages of projects may help managers focus on the critical areas.

4. Case study data findings

The relevant research findings need to be compared against case studies to determine if the research is valid in terms of its contribution to the existing body of knowledge. The case studies chosen were typical residential building construction projects located in Trinidad and Tobago. The criteria for the case studies is to compare the findings of the research against what really exists on the construction projects. The data collection process is the same as for the research project. Specific to this case study, an interview was conducted with the project manager to gather the information. After the data were gathered and sorted, the answers to the questions in the interview were compared to the findings of this research in a table format. From these findings, gaps and similarities were identified thus allowing for conclusions and recommendations. Table 9, next page, illustrates the results.

The results from the case study revealed a number of findings which will be discussed here. 80% of the construction sites agreed that pre-investment risks had a major influence on project success. This is also validated in the research findings and writings of other researchers as highlighted in the literature review. The earlier that risks are detected, the more efficiently they can be mitigated against.

Also, all of the high and low impact risks identified in the case study sites were included in the research findings. No site had all of the risks listed in the research findings. This can be partly attributed to the fact that risks are harder to be identified in the pre-investment stage of typical buildings construction projects locally. One hundred per cent of the case studies agreed with this fact. Further to this 80% of the sites agreed with the fact that more time spent in the pre-investment stage of a project can lead to project success. The same 80% also agreed with the point that it should be mandatory to prepare detailed pre-investment risk assessments in the feasibility study. As discussed in the earlier part of this chapter, the Inter-American Development Bank and the World Bank highlighted, through research, highlighted the need for more time to be spent in the pre-investment stage in Latin America and the Caribbean. This is a fact also agreed with 93% of the respondents in the sample population survey. Part of the problem associated with pre-investment risk assessments in residential buildings construction projects is that professionals cannot thoroughly put together a list of all the potential risks associated with the pre-investment stage. This, and how to accurately rate the risk probabilities are major shortcomings in the industry.

Sixty per cent of the cases agreed that risks should be rated randomly to ensure accuracy of a true probability outcome and less biasness. There is no analysis approach for risk ratings done locally identified to date. Because of this, risk assessments are done via expert judgement. The risk assessor is a key factor with rating of the risks.

This research will therefore allow assessors to have a more confident attitude towards risk assessment. 80% of the cases interviewed were in agreement that the background of the risk assessor is more important than risk experience. The general consensus is that it is very possible to be preparing the risk assessment documents incorrect for a long period of time, this is bad risk experience. But someone with a senior professional background in the construction industry should be able to identify the shortcomings of an incorrectly prepared risk assessment document. This is where the expert judgement is still critical in the process. Even after an analytical approach has been adopted a thorough review still needs to be done to ensure validity.

The sector in which the risks are being assessed are important as well. One hundred per cent of the cases agreed that there is a difference between private and public sector risk assessments. The main explanation is that public sector risk assessments are generally more bureaucratic than the private sector’s. This is also validated in the research findings.
### Table 9. Case study findings

| Case Study Model | Case Study 1 | Case Study 2 | Case Study 3 | Case Study 4 | Case Study 5 | Research Findings |
|------------------|--------------|--------------|--------------|--------------|--------------|------------------|
| Is pre-investment risk assessments a major influence on the project success? | ✓ | X | ✓ | ✓ | ✓ | ✓ |
| Were the high impact risks identified included in the research risk listing? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Were the low impact risks identified included in the research risk listing? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Do you agree with the ranking of the risk priorities? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Do you agree with the top five being selected as the major influences? | X | ✓ | ✓ | ✓ | ✓ | ✓ |
| Is it important that the risk assessment is rated with risk matrix values? | X | X | ✓ | ✓ | ✓ | ✓ |
| Were there any unforeseen risks? | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| Was any data analysis used? | X | X | X | X | X | ✓ |
| Is it difficult to identify risks in the pre-investment stage? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Is the background of the risk assessor more important that risk experience? | ✓ | ✓ | ✓ | ✓ | X | ✓ |
| Is there a difference between private and public sector risk assessments? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Do you think that more time spent in the pre-investment stage risk assessment can increase project success? | ✓ | ✓ | X | ✓ | ✓ | ✓ |
| Should it be mandatory to prepare detailed pre-investment risk assessments in the feasibility study? | ✓ | ✓ | X | ✓ | ✓ | ✓ |
| Do you agree that, locally, more attention needs to be spent on professional training for risk assessors? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Do you think the risks identified in the research findings should be included in typical residential buildings construction projects? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
Based on the case study model as seen in Table 9, the research findings have been validated with actual building construction projects in Trinidad and Tobago. One hundred percent of the cases agreed with the risk priority listing obtained from the research findings. Finally, 100% also agreed that more attention needs to be spent on professional training for risk assessors. This is an overlooked gap for most professionals in the industry. It can be argued that this training is obtained in a Masters level degree, but without specific training for pre-investment risk assessments in typical buildings construction projects, the industry is losing out on potential investments. This in turn has a domino effect on the employment of construction professionals in the economy.

5. Conclusions

5.1. Objective 1
The prevalent risk parameters in the pre-investment phase of typical residential building projects in Trinidad and Tobago were identified. Fifteen risks were found that contribute to the decision-making process specific for this research.

5.2. Objective 2
The risk parameters identified that impacts on the pre-investment phase of a typical residential building construction project with regards to cost, time and quality are availability of direct labour, engineering designs, availability of materials, project scheduling, and project management, respectively. All got a top rating of 64% risk threat. Sustainability and lack of insurances were on the other end of the scale as those with the lowest impact with ratings of 36% and 42%, respectively. Although all of the 15 risks identified were scored in groupings, a distinction was made based on their individual ratings to achieve an order of the risk impacts as per Table 8.

The analysis further revealed the risk parameters with the biggest influence over cost, time and quality were those with a technical background.

The next logical question was then asked in the null hypothesis, if the probability distributions of the cost, time and quality considerations were the same? Based on all the statistical tests at a confidence level of 95%, the results were mainly rejecting the null hypothesis. The 1 sample sign test as seen in Table 5 and three runs of the Chi-square test, as seen in Table 6, all rejected the null hypothesis. However, in the Wilcoxon test, as seen in Table 7, identified that the specific difference between the probability distributions was with cost and quality only.

5.3. Objective 3
This research identified the priorities of the major risk parameters that impact on the pre-investment stage of a residential building project locally. The 15 risks presented in the beginning were validated as the major ones to consider. Although there were a few not considered, these were the major ones. The order of the risks with the most impact changed from the original list presented in the literature review, Table 1.

The risk priorities were validated by the data analysis which tested the robustness of the risk priority model. The cost analysis revealed the most dominance with regards to influence by the risk parameters. Ninety-three per cent of the risk parameters were found to have influence over the cost consideration. With time being influenced by 60% of the risk parameters and quality being influenced by 33% as seen in Table 4.

To determine the validity of these findings, case studies along with expert judgement was used to analyse the research findings. There were five case studies carried out on construction projects across Trinidad and Tobago by means of interviews. Based on the case study model presented in Table 9, the research findings were unanimously validated. All five cases agreed with the priority
ranking of the risks. Also with the fact that these risks should be included in typical residential building projects risk assessments locally.

All respondents were also in agreement that pre-investment risk assessment is important and that more attention needs to be placed on professional training specific to proper preparation of risk assessments. The general consensus was that it is difficult to identify risks in the pre-investment stage of a project, and everyone relies on expert opinions to score them.

Forty-seven per cent of the questions posed in the case study model were agreed with fully by all five cases. Twenty-seven per cent of the questions posed were agreed with by four out of the five cases and the remaining questions, 26%, were agreed with by three or less cases out of the five. All 15 questions posed gained favourable responses that has validated the research findings.

The results of this research illustrated the impacts of the risk parameters on cost, time and quality considerations. And presented the risk parameters in a prioritized order.

5.4. Limitations of the research

The following are the limitations of the research:

The obvious limitation was the time to conceptualize and prepare the research document. This is significant, as all research and data collection has deadlines.

The data collection process was the information received from the respondents of the survey. Although careful supervision was made during the surveying exercise, it is not 100% guaranteed that all respondents were honest about their opinions when answering the questions.

There are no doubt more limitations in this research paper, but these are the main ones focused on by the author.

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