International Journal of Science, Environment and Technology, Vol. 4, No 3, 2015, 690 – 700

ISSN 2278-3687 (O)
2277-663X (P)

STAKEHOLDER IMPACTED COST CONTINGENCY MODEL (SICC)

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Abstract: In 2007, the Federal Transit Administration, an arm of the US Department of Transportation, published a detailed analysis of contractor performance for specific transit projects across the United States, including the downtown Seattle tunnel project. The project was estimated to cost less than $299.6 million, but it was eventually completed for $468.7 million. Among the reasons for the cost overrun were mainly the complaints from downtown municipality interests. The major problem facing project managers is the inefficient stakeholders' cost contingency procedures being the main cause behind the project's cost overrun. This paper develops the Stakeholder Impacted Cost Contingency (SICC) model. The SICC model is used to evaluate the stakeholders' cost contingency of a project. The model considers five main stakeholders of the project: the project manager, the client/owner, the engineer, the contractor and the government. The developed model analyses the complete project life cycle: the conceptual phase, the design phase and the construction phase. The SICC model i) uses the Analytic Hierarchy Process (AHP) in order to evaluate each stakeholder power weight in each phase; ii) then uses Fuzzy Set theory (FST) in order to evaluate each stakeholder influence in each phase; iii) it uses the Multi-Attribute Utility Theory (MAUT)in order to evaluate each stakeholder impact on cost in each phase; finally iv) it determines the project Stakeholder Cost Contingency (SCC). This research is relevant to project managers and academic researchers, since it develops a tool for evaluating the cost contingency of projects due to stakeholders influence.
Keywords: Stakeholders, Cost Contingency, Project Life Cycle.

INTRODUCTION

Evaluating stakeholder influence on a project is one of the major concerns in modern project management, both in academics and industry. For instance, according to Garcia (2012), the famous Sydney opera house had a cost overrun of 95 million Australian dollars, while it was originally budgeted for 7 million Australian dollars only and it ended up with a cost of 102 million Australian dollars.

The major problem that faces projects is the lack of good stakeholder management. The lack of proper stakeholder management is directly linked to the lack of managing and balancing

*Received April 21, 2015 * Published June 2, 2015 * www.ijset.net*

stakeholders' needs and assessing their impact on the project cost. Therefore, there is a need to develop a contingency model used to assess the influence of the stakeholders on the project cost.

The paper focuses on a quantitative assessment model of stakeholders' impact on the project cost, entitled the 'Stakeholder Impacted Cost Contingency' (SICC) model. The model is applicable to any type of projects along the project life cycle. The SICC model evaluates a cost contingency due to direct stakeholders' influence, the Stakeholder Cost Contingency (SCC). In order to fulfill this main objective, the following sub-objectives are identified: i) identify main stakeholders, ii) evaluate stakeholders' power weights, iii) evaluate stakeholders' likelihood of interference, iv) evaluate stakeholders' impact level on the project, and v) evaluate project Stakeholder Cost Contingency (SCC).

BACKGROUND

Stakeholders are individuals, groups, or institutions who can affect the outcome of a project, either negatively or positively. However, their influence is neither similar to all, nor the same along the life of the project. Researchers have long tried to analyze and assess stakeholders influence on projects.

Table 1 shows the most important researches done on stakeholders influence on projects, with their respective limitations. It is observed that no previous research has focused and/or developed a quantifiable model that assesses a project cost contingency due to stakeholders influence, over the project life cycle. The SICC model fills this lack in the project management body of knowledge.

Table 1. Summary of Researches on Stakeholders Influence on Projects

Researcher	Main topic	Limitations
Frooman (1999)	Stakeholders influence strategies	Fails to develop a quantitative influence measure of the stakeholders to the project.
Cleland (1999)	Simple approach in order to visualize stakeholders and their likely impact and influence.	Lack of assessing the impact of each stakeholder interest on the project and along the project life cycle. Does not evaluate a quantitative level of interest of the stakeholders to the project.
Olander and Landin (2005)	Analysis, using a case study, of the problems of managing the concerns of stakeholders.	The dependency of the model on a case study only.

Olander (2007)	Developed a model that evaluates stakeholder impact on projects by calculating an impact index.	More attributes should be considered.
Walker *et al.* (2008)	Stakeholder Circle that shows visually the stakeholder positive or negative importance on the project.	The stakeholder circle fails to quantify an impact on the project The circle is not a friendly tool.It does not consider the stages of the project life cycle.
Nguyen *et al.* (2009)	Stakeholder Impact Analysis (SIA) model	Quantification of the impact on the project is missing. The model fails to assess the impact at different stages of the project life cycle.
Chandra *et al.* (2012)	The role of stakeholders in project success	The influence of stakeholders on project success accounts for three factors only: stakeholder impact, stakeholder engagement and stakeholder psychological empowerment. The model fails to assess the influence at different stages of the project life cycle.

THE STAKEHOLDER IMPACTED COST CONTIGENCY (SICC) MODEL

The Stakeholder Impacted Cost Contingency (SICC) model evaluates a cost contingency due to the different stakeholders' influence on the project in its conceptual, design and construction phase. The SICC model assesses: i) quantitatively the stakeholders influence on the project cost during the project life cycle, and ii) the cost contingency due to the stakeholder influence over the project life cycle. The SICC model flow diagram is illustrated in Figure 1.

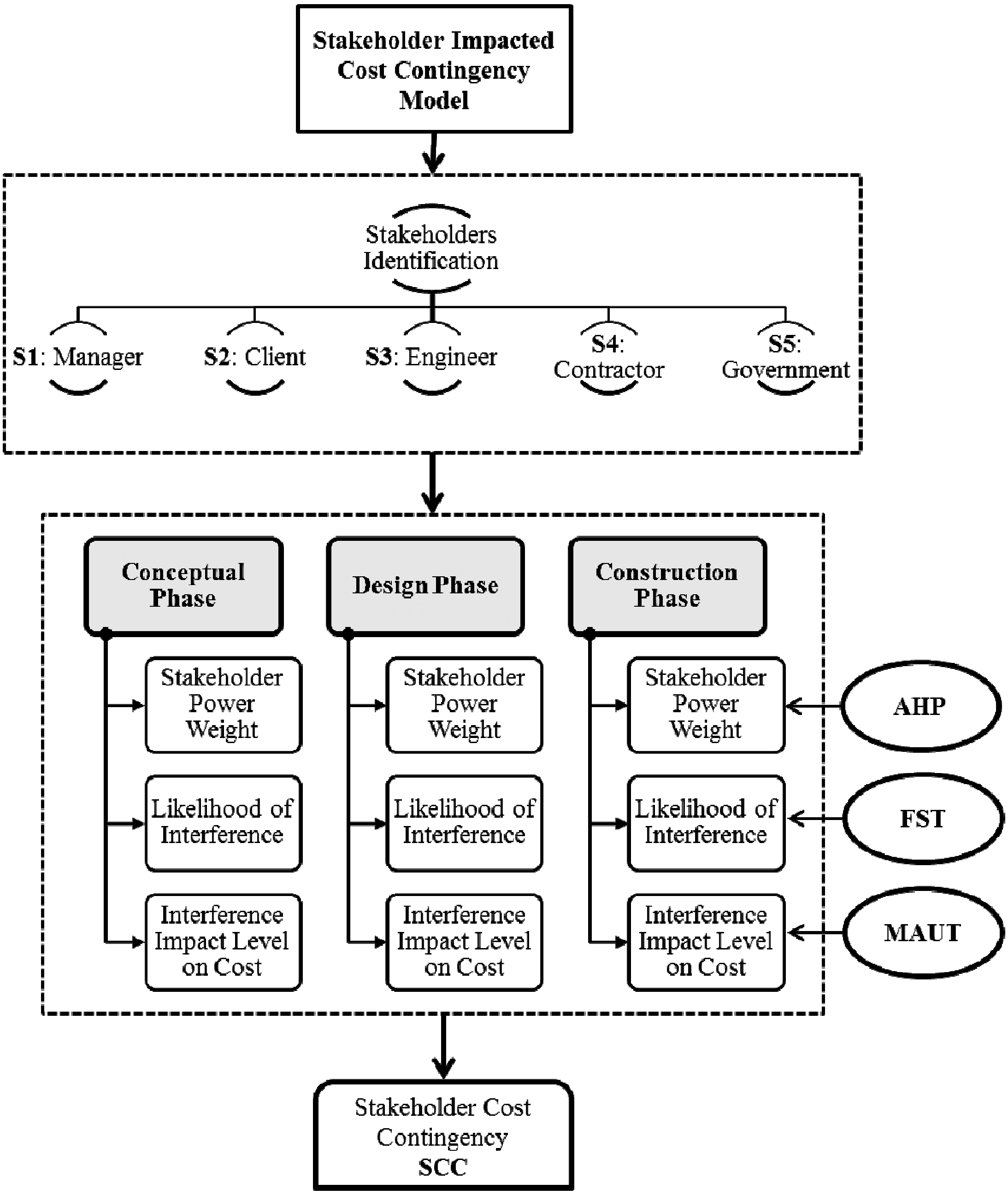

Figure 1: Stakeholder Cost Contingency Model Flowchart

Main Stakeholders Identification

The SICC model considers five (5) main stakeholders. Based on both the literature review and expert surveys, five (5) main stakeholders are regarded as the most important, influential and representative. The five main stakeholders are identified as follows:

1. Project manager (**S1**): the project manager is the person in charge of the overall planning and execution of particular project.

2. Client (**S2**): the client is the person who is either the owner of the project or the project sponsor.

3. Engineer (**S3**): the engineer is the person is the person in charge of the design of the project.

4. Contractor (**S4**): the contractor is the supplier, the manufacturer, the vendors or the sub-contractor.

5. Government (**S5**): the government is either the municipality or the governing authority.

Stakeholders Power Weights

The power weight is a measure of the power each stakeholder has on the project goals. Power weights are evaluated in the SICC model using the Analytic Hierarchy Process (AHP) method. AHP, developed by Saaty (1980), is a scientific mathematical method that compares stakeholders two-by-two based on their power to interfere in the project. A power weight is evaluated in the SICC model in each of the three stages of the project, the conceptual, design and construction phases.

AHP uses a comparison scale of 1 to 9 (*1 = equally important, to 9 = very strongly more important*).

A sample of AHP pair-wise comparison matrices is shown in Table 2. A matrix is prepared for each project phase.

Table 2. AHP Pair-Wise Comparison Matrix

	S1	**S2**	**S3**	**S4**	**S5**
S1	1	a_{12}	a_{13}	a_{14}	a_{15}
S2	$1/a_{12}$	1	a_{23}	a_{24}	a_{25}
S3	$1/a_{13}$	$1/a_{23}$	1	a_{34}	a_{35}
S4	$1/a_{14}$	$1/a_{24}$	$1/a_{34}$	1	a_{45}
S5	$1/a_{15}$	$1/a_{25}$	$1/a_{35}$	$1/a_{45}$	1

Where a_{12} (for example) is the level of importance stakeholder 1 has on stakeholder 2, in terms of power weights, based on the AHP scale of comparison.

Let W_{Sj} be the power weight of stakeholder *j*. So, W_{Sji} is the power weight of stakeholder S_j in the project phase *i*.

Thus, the sum of power weights in each project phase equates unity, as per Equation (1).

$$\sum_{j=1}^{5} w_{S_{ji}} = 1 \qquad (1)$$

Where, j = 1 to 5; No. of stakeholders

And, i = 1 to 3; Project phase:1=conceptual phase, 2=design phase, 3=construction phase.

Stakeholders Likelihood of Interference

The SICC model evaluates the likelihood to be subjective and ranging from 'Very High' (VH) to 'Very Low' (VL). Due to the subjective nature of the Likelihood of interference, the SICC model defines it as a triangular fuzzy number. Fuzzy Set Theory (FST) is the best method to model uncertainty. The SICC model, using expert surveys, evaluates the stakeholder membership function as illustrated in Figure 2.

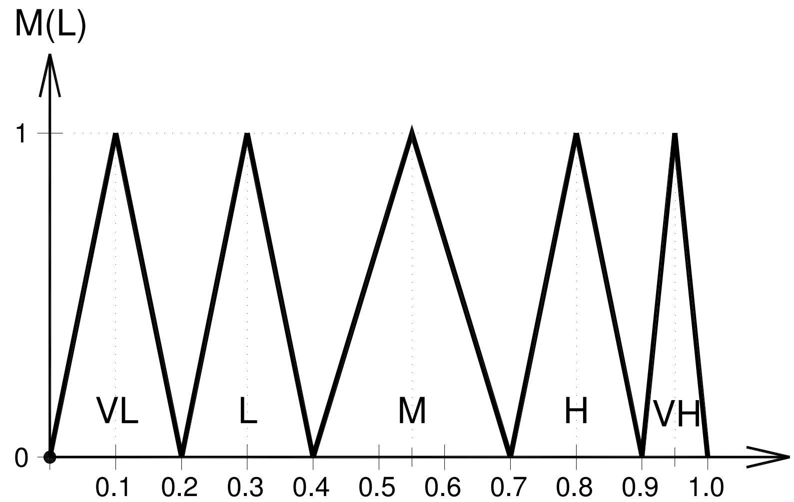

Figure 2. SICC Likelihood of Interference Fuzzy Membership Function

The SICC model evaluates the stakeholder likelihood of interference as the Expected Value (EV) of the fuzzy membership function, i.e. $EV_{M(L)}$, defined as L_{Sji} in Equation 2.

$$L_{Sji} = EV_{M(L)ji} \pm V_{M(L)ji} \qquad (2)$$

Where L_{Sji} *= Likelihood of interference crisp value for stakeholder* S_j*, in project phase i,*

$EV_{M(L)}$ *= Expected Value of the Likelihood fuzzy membership function,*

$V_{M(L)}$ *= Variance of the Likelihood fuzzy membership function.*

Table 3 shows the stakeholder likelihood of interference evaluation.

Table 3. Stakeholders Likelihood of Interference Evaluation

Likelihood Description	Fuzzy Membership Function Parameters M(L)			Fuzzy Expected Value	Fuzzy Variance*	**Stakeholders Likelihood of Interference**
	m_1	m_2	m_3	$EV_{M(L)}$	$V_{M(L)}$	L_{Sji}
Very High (VH)	0.9	0.95	1.0	0.95	0.04 %	**0.95**
High (H)	0.7	0.8	0.9	0.8	0.16 %	**0.80**
Moderate (M)	0.4	0.55	0.7	0.55	0.37 %	**0.55**
Low (L)	0.2	0.3	0.4	0.3	0.10 %	**0.30**
Very Low (VL)	0.0	0.1	0.2	0.1	0.16 %	**0.10**

*Negligible

Stakeholders Impact Level on Cost

The Stakeholders' impact level on indicates the level each stakeholder can change the project cost objective. The SICC model evaluates the stakeholders' impact level on the project as the level of change on the cost. This impact is subjective and descriptive in nature and varies from 'Very High' (VH) to 'Very Low' (VL). The SICC model in this particular case uses the Multi-Attribute Utility Theory (MAUT), in order to evaluate an impact level as a utility. This impact level utility, associated to the descriptive scale is now quantifiable. It must be noted, that the SICC model, following input of experts, developed a risk neutral utility function of the impact level. Table 4 shows that stakeholders impact level on the project evaluation.

Table 4. Stakeholder Impact Level on the Project Evaluation

Stakeholder Impact Level Description	Impact Level Utility Evaluation	**Stakeholders Impact Level Evaluation** I_{Sji}
Very High (VH)	20%	**0.20**
High (H)	15%	**0.15**
Moderate (M)	10%	**0.10**
Low (L)	5%	**0.05**
Very Low (VL)	1%	**0.01**

Stakeholder Cost Contingency (SCC)

The SICC model evaluates the outcome of the stakeholders' influence on the project cost – or cost contingency – as the weighted average of: i) power weight of each stakeholder in each project phase (W_{Sji}), times the ii) likelihood of interference of each stakeholder in each project phase (L_{Sji}), times the iii) impact level of each stakeholder on the project cost of each project phase (I_{Sji}). Thus, the SICC defines the Stakeholder Cost Contingency (SCC) in Equation 3.

$$SCC = \frac{1}{3}\left[\sum_{i=1}^{3}\left(\sum_{j=1}^{5} W_{S_{ji}} \times L_{S_{ji}} \times I_{S_{ji}}\right)\right] \quad (3)$$

Where SCC = Stakeholder Cost Contingency,

S_{ji} *= Stakeholder j in project phase i,*

W_{Sji} *= Stakeholder j power weight in project phase i,*

L_{Sji} *= Stakeholder j likelihood of interference in project phase i,*

S_{ji} *= Stakeholder j impact level in project phase i,*

j = 1 to 5, main stakeholders,

i = 1 to 3, project phases.

APPLICATION OF THE SICC MODEL TO A CASE STUDY

Fifteen (15) project case studies were provided for the application. Table 5 identifies the project case studies, with their respective titles, locations and initial budget.

Table 5: Project Case Studies

Project Case Study Identification	Project Title	Location	Initial Cost Estimate
Q1	New Doha International Airport Terminal Building	Qatar	770,000,000 $
Q2	Khalifa' Stadium Renovation	Qatar	326,000,000$
Q3	Doha Expressway	Qatar	450,000,000$
Q4	North/South Extension to Ras Abou Abboud Road	Qatar	250,000,000$
Q5	Sports City Tower	Qatar	200,000,000$
Q6	Qatar Foundation Headquarters	Qatar	150,000,000$
Q7	MIDMAC Main Office	Qatar	18,000,000$
Q8	Olympic Committee Headquarters	Qatar	20,000,000$
Q9	QIPCO Residential Compound at West Bay	Qatar	50,000,000$
Q10	Qatar National Convention Center Extension	Qatar	465,000,000$
Q11	Tornado Tower	Qatar	465,000,000$
Q12	Barwa Ain Khalid Commercial Development	Qatar	965,000,000$
Q13	Barwa Al Sadd Complex - Office Building	Qatar	659,000,000$
Q14	Barwa Financial District	Qatar	1,360,000,000$
Q15	Burj Al Marina Hotel	Qatar	360,000,000$

The power weights were collected through questionnaires, and a statistical analysis was performed. The statistical analysis proved that the power weights follow a normal distribution (with a small error), and the average values can be used with 95% confidence level. Table 6 shows the average power weights for each project phase.

Table6. Stakeholder Power Weights Average Values

Stakeholders	Stakeholders Power Weights		
	Conceptual Phase	Design Phase	Construction Phase
S1: Manager	0.12	0.13	0.18
S2: Client	0.33	0.24	0.23
S3: Engineer	0.13	0.26	0.15
S4: Contractor	0.12	0.13	0.20
S5: Government	0.29	0.24	0.23

The model is applied to all the projects of the case study in order to evaluate the contingency cost of these projects, and the SCC values are plotted in Figure 3.

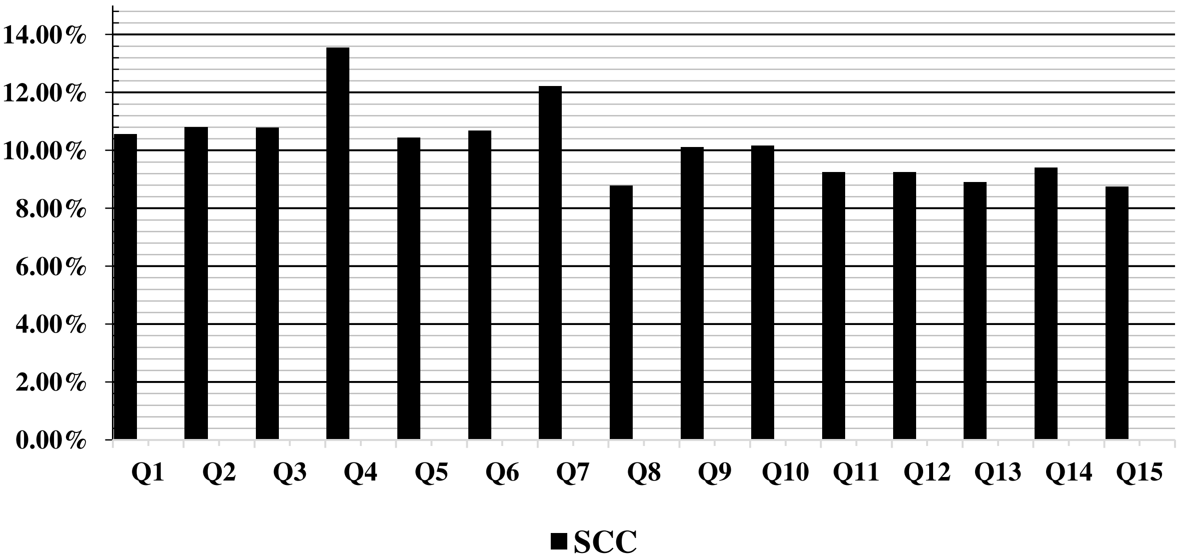

Figure 3: SCC Distribution in Case Study Projects

The SCC of the case study projects are somehow close and ranging between 8% and 14%, regardless of the budget. A statistical linear regression was performed, and it was found that no correlation exist between the budget and the SCC results. Since the SCC is found to be around 10% for all projects in this case study, a statistical analysis and normality tests is performed in order to prove that this figure can be used generically for all projects. The statistical analysis has proved that a figure of Stakeholder Cost Contingency (SCC) of 10% is not generic, and a SCC value should be evaluated for each project separately.

In order to confirm the results of the SICC model application to the case study, a sensitivity analysis is used in order to study the effect of the stakeholders' power weights on the SICC results. The purpose of this type of analysis is to check the variation of the outputs (SCC) due to the change in the inputs (stakeholders' power weights). This sensitivity analysis is also necessary to check the effect of subjectivity and inconsistency of AHP mathematical calculation in the SICC model results. The range of the change in the power weights is the same range used in the statistical analysis (95% confidence interval from the mean). This sensitivity analysis assumes a change of the power weights of ±40% of the mean value. The sensitivity analysis is performed using @Risk software. The project with the highest initial cost (budget), chosen from the first part of the collection of the project case studies, and the highest SCC were chosen for the analysis, which is in this case project Q1. Figure 4 show the Tornado graph of the sensitivity analysis results for project Q1.

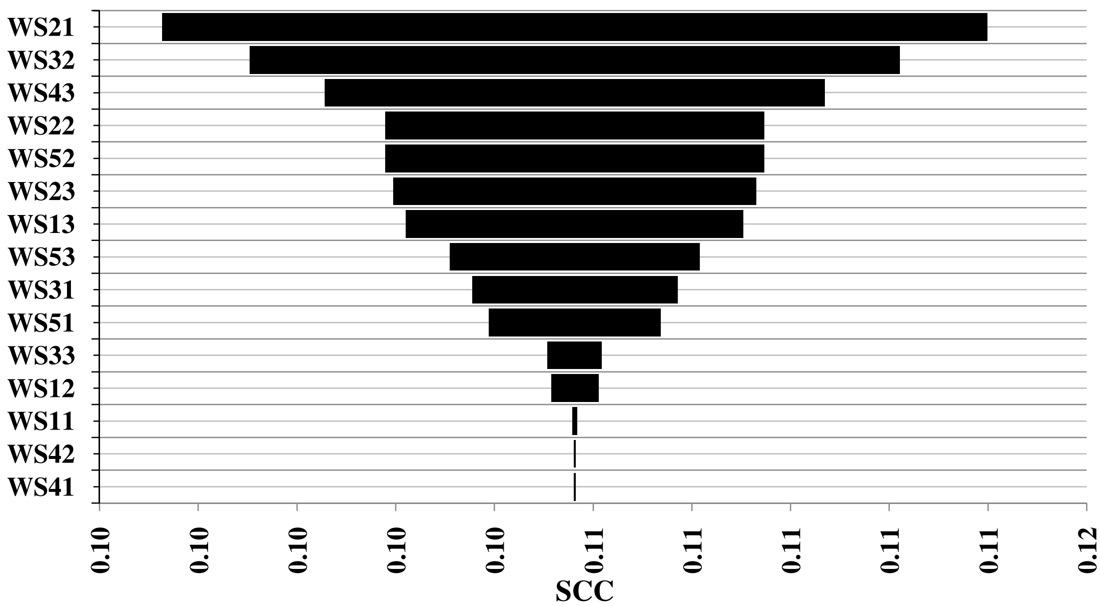

Figure 4: Tornado Graph for Sensitivity Analysis for Q1 Project

It can be observed that the SCC values are sensitive to stakeholder S2 (client) change in power weights, specifically in the conceptual phase. Actually, this observation is true since the client can do tremendous changes as owner of the project in this preliminary phase of the project. Furthermore, the effect of the stakeholder power weight change on the SCC is ±8% of the original result, which is relatively small. It can be concluded that although the SCC is sensitive to any change in the power weight, its change is small to neglect it. This means that the SICC model considers with confidence inconsistencies, subjectivity and scarce data in the evaluation of the stakeholders power weight.

CONCLUSION

A new model for evaluating stakeholders' influence on projects cost was developed. The Stakeholder Impacted Cost Contingency model (SICC). Based on the average power weights evaluated using the Analytic Hierarch Process (AHP), the client has the highest power weight during the conceptual phase (33%). The engineer has the highest power weight (26%) during the design phase. And the contractor has the highest power weight (20%) during the construction phase. Based on the sensitivity analysis the effect of the stakeholder power weight change on the SCC is around ±8% which is relatively small, this means that although the SCC is sensitive to any change in the power weight, its change is small. The SICC model considers with confidence inconsistencies, subjectivity and scarce data in the evaluation of the stakeholders power weight.

The model developed in this research enhances existing and encourages future researches in the field contingency management.

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