A decision support system (DSS) for facilitating the scenario selection process of the renegotiation of PPP contracts

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Abstract

Purpose – Public private partnership contracts tend to have longer contract durations compared to other conventional procurement methods. A contract renegotiation becomes inevitable in most of the cases. The renegotiation process usually develops a number of scenarios in order to regain the contract equilibrium. The purpose of this paper is to facilitate the renegotiation process by offering an automated system to select the optimum renegotiation scenario that preserves the rights and the interests of the project stakeholders.

Design/methodology/approach – The common renegotiation scenarios used are: increasing the service charges, increasing the concession period or paying a lump sum amount to the party of concern in order to maintain a fixed rate of return and keep the return on equity constant. In this paper, a method of selecting the optimum scenario among the different scenarios is proposed. This is done using a weighted sum model to calculate the weights and ranks of a number of factors influencing the stakeholders' decisions. A DSS is developed with the aid of Microsoft Excel, VBA programming language, and the Precision Tree 5.5 for Excel add-in.

Findings – The renegotiation process has been facilitated by using an automated system that maximizes the benefits of both the public sector and the private sector. The optimum renegotiation scenario has been selected for the case of the model.

Originality/value – The developed framework is of great benefit to project stakeholders, including the private sector, the public sector and the users of the service. It saves time and money invested in lengthy negotiations, and it enforces transparency and mutual trust between the different parties by providing a tool that significantly minimizes conflicts during the renegotiation process and defines clear steps to be followed in order to reach an agreement that will maximize the benefits for both the private and the public sectors.

Keywords Contract, Public private partnership (PPP), Management, Case study, Project management, Decision support systems, DSS, Spreadsheet, Renegotiation, Financial model, Re-equilibrium

Paper type Research paper

Introduction

Public private partnership (PPP) is a delivery method which depends on co-operation between the public sector and the private sector in order to be able to finance mega infrastructure projects. PPP contracts include one or more of the following components: design, build, finance, operate, maintain, own, transfer, lease, develop, buy or refurbish. The combinations of those trades usually vary depending on the level of involvement of the private sector, the ownership status of an asset and the source of financing (Davies and Eustice, 2005). The choice between the PPP delivery method and other conventional delivery methods depends on many factors that should be looked at thoroughly. One of the main factors is the value for money (VFM). The VFM is the difference between the project value that is incurred by the private sector in case of choosing the PPP option and the project value if executed by the public sector. Although the cost of borrowing for the private sector is usually much higher than the cost of borrowing for the public sector, the PPP option, in many cases, may have a higher VFM for several reasons, such as the ability of the private sector to provide better and more efficient services than the public sector (The Construction Management Association of America, 2012). Private sector know-how is another reason for choosing a PPP approach. A VFM study should be conducted to determine whether the PPP option is more efficient in the long run than other procurement methods. In other words, the

public sector should only choose the PPP option over conventional procurement methods when the private sector is providing a better service with more efficiency, or when the private sector is providing a higher VFM.

Despite the above benefits, PPP projects are very challenging in terms of attracting investors to enter the bidding process. This is due to several factors; one of which is the private sector's fear of the long-term nature of PPP projects, which makes it extremely difficult to anticipate contingencies along the projects' lifecycles. Due to the lengthy contract durations, the principles and bases upon which the original PPP contract was made may no longer apply; they may be simply altered or totally changed as the project evolves. A different set of conditions and situations may appear later in the project, making the need for a contract re-equilibrium inevitable and with re-equilibrium comes renegotiation. During the renegotiation stage, conflicts may arise between the different stakeholders of the project. These lengthy renegotiations become full of conflicts that, in some cases, may lead to contract terminations and major losses for several parties. However, those conflicts can be avoided through a pre-agreed renegotiation mechanism. Tools are needed to ease the lengthy renegotiation process. This research provides a tool that facilitates a renegotiation process in which the interests of all parties are considered in the final decision. This tool will help in attracting the private sector to enter PPP contracts and ensure project continuity and stability of transactions.

Literature review

Almost all PPP advantages lead to the same conclusion: a better VFM. According to Skanska," the net present value of a public project consists of the whole life cost of procuring services, the cost of finance, and the cost of risks retained by the public sector, as shown in Figure 1 (Skanska, 2004). When going for the PPP option, the public sector reduces the whole life cost of procuring services and the cost of risks retained by the public sector; however, it increases the cost of finance.

According to Guan-Weiin order to make a PPP more beneficial, a balance should be obtained to ensure that the summation of all the benefits and drawbacks achieves, in the end, a positive value for the public sector: the VFM (Guan-Wei, 2010).

Herpen states that the VFM is achieved due to several factors. First, instead of the public sector bearing all the risks, the PPP approach allows the public sector to transfer many risks to the private sector; moreover, PPP contracts are output-based contracts, meaning that the private sector shall only be paid when providing the service as per the specifications required.
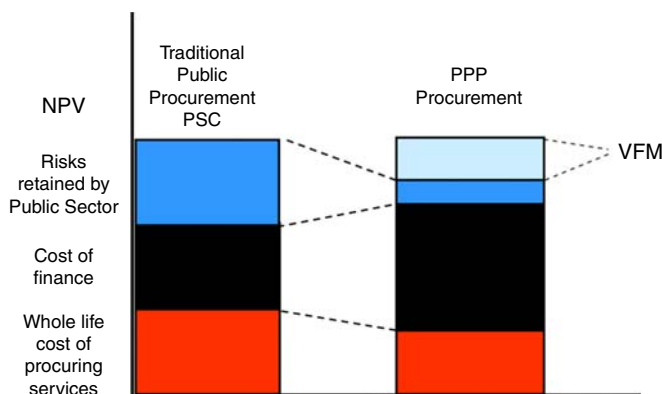

Source: Skanska (2004)

Figure 1.
Value for money
(VFM) of PPP

In addition, the private sector is obliged to provide the public sector with the whole life cost of the project in advance, despite the long-term nature of the PPP project. Due to all of the above, PPPs promote cost efficiencies and provide improved service (Herpen, 2002).

Archer and Cameron published results of a survey conducted by the National Audit Office of the UK. The survey included 37 PPP projects. Cost overruns and time delays were estimated. The results indicated that almost 75 percent of conventional procured projects suffer from cost overruns while less than 25 percent of PPP projects suffer from cost overruns. The study also found that almost 24 percent of PPP projects suffer from time delays. The conclusion showed that PPPs are more efficient in terms of time and cost than conventional procurement methods (Archer and Cameron, 2003).

Connolly and Wall explains another advantage of PPP which is value capture. They state that the existence of PPP projects which involves enhancing the infrastructure network, transit facilities and other services of a certain area, shall increase the value of properties and land. This shall lead to flourishment and economic growth of a country. The value capture allocates some of the financial value of those benefits to users which helps in removing some of the burden from the public sector (Connolly and Wall, 2016).

The Construction Management Association of America states that one of the main advantages of PPPs are that they delay the need of the public sector to use the funds in the public treasury. In other words, they allow the public sector to use the capital in the public treasury for other projects and minimize the need for raising taxes to meet the demands of infrastructure projects. However, the government should be very careful when planning for future spending, considering the operation costs of PPP projects after they are transferred to the government (The Construction Management Association of America, 2012).

Sarmento and Renneboog have explained another aspect similar to the above which is called "off-balance sheet" approach. The concept was explained as an advantage to the governments using PPP delivery method. PPP value is not part of the government expenditures listings; in other words, it is off their balance sheet. Hence, theoretically, it will not affect the public debt (Sarmento and Renneboog, 2016).

Another advantage of PPPs are their quick responses to customers' needs, which are usually more efficient in the case of the user-fees payment method. PPPs also provide an incentive and high potential for early delivery of the service, as the private sector wants to maximize the operation period in order to obtain higher profits. Many governments nowadays encourage the PPP option, creating an atmosphere of mutual cooperation and a better work environment for the private sector investors, which is another main advantage. The PPP option provides a non-depleting source of resources to meet the public demand for new services and infrastructure projects (The Construction Management Association of America, 2012).

The VFM can be a great advantage of PPPs, as shown above; however, if not studied thoroughly, it can be also a major disadvantage if the conventional procurement methods become more efficient. PPPs have many additional costs that the public sector must bear, such as tendering, administration and transaction costs. Moreover, poor drafting of contract terms can lead to renegotiation, resulting in the private sector being overpaid for the service. Again, the cost of borrowing for the private sector is much higher than for the public sector, which also should be weighed against the other gains of PPPs.

Katzstates that due to the length of PPP contracts, such contracts are usually prone to renegotiation as a result of various unexpected contingencies that might occur along the project lifecycle. In addition, it is very difficult to control the performance of the private sector and its quick response to growing demand, especially when the private sector is paid by the government rather than the user fees method. This may lead to political issues due to the dissatisfaction of the service users. A PPP contract may lose efficiency with time due to the fact that the project cannot be re-tendered, which diminishes competition and the incentive to provide a better service (Katz, 2006).

Li *et al.* have investigated the different factors that affects the attractiveness of PPP contracts. They state that PPP provides a better technology and economy to the project. In addition, it eliminates regulatory and financial constraints enforced by the public sector strategy. Also, they have mentioned the benefit of reducing the transaction costs (Li *et al.*, 2005).

Cruz and Marques has investigated the reasons of contract renegotiation in infrastructure projects. They claim that contract renegotiation is usually a result of contract incompleteness. Cruz and Marques states that in order to have a complete contract, this will result in a very high transaction costs. Hence, instead of working on a complete contract, some rules and conditions are to be agreed in case of renegotiation (Cruz and Marques, 2013).

Cruz *et al.* has stated that the main reasons of renegotiation vary between changes initiated by the government and changes in the expected return of the project. The event which occurs after the award of the project leads to a completely new risk matrix with different allocation of the risks and risk allocation (Cruz *et al.*, 2015).

Guasch states that the aim of PPPs is to encourage better private sector quality and performance for the benefit of users. In the long run, the private sector records efficiency gains that should be passed to the users in the form of lower tariffs. However, it has been shown in different studies that these efficiency gains have a weak correlation with tariffs and usually reflect on a minor portion of them. According to Guasch, the efficiency gains are reflected only in 1 percent or less of the tariff value. In some cases, the government chooses to obtain those efficiency gains indirectly by increasing the taxes (Guasch, 2004).

In summary, the idea of a PPP is to combine the expertise and resources of the public and the private sectors in order to reach efficiency and VFM, yet PPP if not carefully managed, it can increase the cost of procurement services more than any other traditional procurement method (Carbonara *et al.*, 2016). The above disadvantages along with insufficient feasibility studies and poor decisions can turn a PPP from an advantageous method of delivering services to the public sector into leading to undesired results.

Renegotiation can have many triggers which has been studied by many researchers. According to Garvin, one of the most important factors in the renegotiation process is the mutual trust between the different parties, which leads eventually to sustainability. The key aspect of this approach is sharing benefits and risks among the different parties of the PPP through the contract agreement; however, some problems and unforeseen risks may occur during the construction and the operation that have not been included within the contract clauses. Garvin has studied different incentives mechanisms through some contract clauses in order to make those clauses flexible to absorb any risks arising after the commencement of the project and minimize the need for renegotiation (Garvin, 2009).

Roach also recommends establishing an "independent auditor" within the public sector to be responsible for all the PPP projects in the state or government. Roach suggests that the independent auditor be formed by five members who have knowledge and experience in the PPP field. The advantage of such an institution is to avoid conflicts between the different governmental institutions involved in the PPP process that may lead to the failure of PPP projects. Roach states that the auditor will prevent any initiations of conflicts of interest and will help in the process of renegotiation in general (Roach, 2011).

Other than the above recommendations, the contract designer of a PPP project should apply some adjustments in order to ensure a well-defined path for the renegotiation process to avoid unfavorable solutions, such as termination. Dewatripont and Legros recommend that PPP contracts have a clear method of output indicators. They also suggest a clear procedure to revise the different cost items and evaluate the investments and assets of the project. Moreover, PPP contracts should include a clear method of conflict resolution and early termination (Dewatripont and Legros, 2009).

The methodology
This framework is a fragment of a comprehensive research which aimed to developing the re-equilibrium scenarios of PPP, and selecting the optimum scenario which fits both the public and the private sector. The framework consisted of eight modules: a User-Interface Module, a Risk Allocation Module, a PPP Valuation Module, a Financial Model Re-equilibrium Module, a Scenarios Development Module, a Scenarios Selection Module, a Reports Module and a Sensitivity Analysis Module. However, for the purpose of this paper, the research shall focus on the scenario selection process.

The aim of this paper is to demonstrate the part of the project which is concerned with the facilitation of the PPP renegotiation process by choosing the optimum scenario to satisfy all parties. Stakeholders have different interests and concerns in the renegotiation process; hence, the proposed model will work on finding common ground between all parties in order to reach an optimum renegotiation outcome. This will ensure a fair approach and enhance mutual trust between the stakeholders, which will benefit the project's overall progress. The following framework is to be of great benefit to decision makers in the public and the private sectors, yet the objective of the proposed framework is not to be a substitute for decision makers.

The Framework has been developed using the aid of Microsoft Excel 2013, Visual Basic for Applications (VBA) programming language, and the Precision Tree 5.5 for Excel add-in. The data used for the purpose of this paper belong to a wastewater treatment plant that is located in New Cairo, Egypt. The results obtained from the model has been validated and published in the Ninth International Structural Engineering and Construction Conference (Shalaby and Hassanein, 2017).

The scenarios selection module
In PPP projects, events occur that disturb the re-equilibrium of the financial model; in other words, it affects the cash flow of the project which may lead to changing the agreed rate of return of the private sector. In order to fulfill the purpose of PPP projects and return the equilibrium to the PPP financial model, there are commonly used four re-equilibrium scenarios which are: paying a lump sum amount to the private sector, increasing the service charges, increasing the concession period, or a combination of one or more of the above. The scenarios selection module is the module in which the choice between the four re-equilibrium scenarios is made. Figure 2 shows the relationship between the scenarios selection module and the other modules. The inputs of the scenarios selection module are from the user-interface module. The outputs of the module go to the reports module and the sensitivity analysis module. The goal of the scenarios selection module is to account for the interests of the stakeholders of the PPP project, mainly the public sector and the private sector, when selecting the renegotiation outcome scenario.
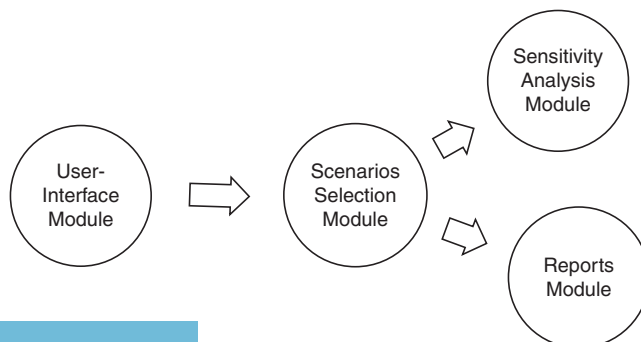

Figure 2.
The scenarios selection module interrelation with the other modules

The user interface module provides the scenarios selection module with the final four re-equilibrium scenarios. The user-interface module also supplies this module with the criteria and their corresponding sub-criteria, based on which the selection is to be made. For the purpose of this paper, suggested criteria have been collected from several professionals in the field in order to act as a defaults setting in the model. However, the user has an option to edit the different criteria and sub-criteria that is important to the public and private sector. The criteria can be agreed upon in brainstorming meetings and added to the model later on. In order to evaluate each scenario, a score shall be given to each scenario. The scenario score is calculated using the weighted sum model. This weighted sum model works by allocating different criteria to each scenario. The criteria will have relative importance to each other. The scenario score shall equal the summation of the weight of importance for each criterion multiplied by its value as shown in the following equation:

$$\text{Scenario Score } (SS_x) = \sum_{j=1}^{m} W_{C_i} W_{S_j} W_{S_j} \quad \begin{array}{l} x = \{1, 2, 3, 4\} \\ i = 1, 2, 3, \ldots, n \\ j = 1, 2, 3, \ldots, m \end{array}, \quad (1)$$

where x is the number of alternatives of scenarios; i the number of main criteria; j the number of sub-criteria of a certain main criterion; W the weights; R the rankings.

After inputting the criteria, the user-interface provides the scenarios selection module with the importance of each criteria with respect to the rest of the criteria for each of the four scenarios. Moreover, it also supplies the scenarios selection module with the importance of sub-criteria with respect to the rest of the sub-criteria of the same category for each of the four scenarios. Then, the scenarios selection module determines the weights of the criteria and sub-criteria with respect to the different re-equilibrium scenarios. The approach is to draw matrices for the main criteria and each of the sub-criteria categories in which the top row is the criteria or the sub-criteria and the rest of the matrix is a mirror image. Decision matrices were invented by Stuart Pugh (1991). An example of the decision matrix is shown in Figure 3. The importance of the criteria with relative to the other criteria is taken from the user-interface module and inserted in the respective position in the matrix. In order to obtain the weight of each criteria, the number of occurrences of each criteria are counted, and the weights are calculated by dividing the number of occurrences of each criteria over the total number of occurrences of all of them. It is important to note that the total number of weights of the criteria or certain sub-criteria of one category should equal to one.

The above exercise is done for the criteria and the sub-criteria for each one of the four scenarios, as the weights may differ when dealing with making a lump sum payment or just extending the concession period. After obtaining the weights of the criteria, rankings are taken via the user-interface module. Separate rankings are required from both the public sector and the private sector in order to reflect their interests and preferences. Using the weighted sum model, eight scenario scores are calculated: four for the four re-equilibrium scenarios from the perspective of the public sector, and the other four for the four

	Criteria 1	Criteria 2	Criteria 3	Criteria 4
Criteria 1		Criteria 2	Criteria 1	Criteria 4
Criteria 2			Criteria 3	Criteria 2
Criteria 3				Criteria 4
Criteria 4				

Source: Pugh (1991)

Figure 3.
Scenario selection criteria decision matrix

re-equilibrium scenarios from the perspective of the private sector. The outputs of this step are the best scenarios or the scenarios with the highest scores from the private sector perspective and the public sector perspective. Then, averages of the private sector rankings and the public sector rankings are taken to calculate the four re-equilibrium scenarios scores from the perspective of both parties. The scenario with the highest score is marked to be the best scenario from the perspective of both prospective.

The reports module

The reports module is the module in which all the results of the previous modules are combined and processed in order to be directed to the user-interface module. The reports module allows the decision maker to look at the broader picture rather than looking at detailed calculations. Figure 4 illustrates the relationship between the reports module and the other modules of the framework.

The reports module provides risk allocation charts showing the portions of the risks allocated to the public sector, the portions of the risks allocated to the private sector, and the portions of the risks shared between the both. The reports module also provides the user-interface module with a report showing the original PPP concession value vs the PPP updated concession value. In addition, the reports module presents the four re-equilibrium scenarios: paying a lump sum amount to the private sector scenario, increasing the service charges scenario, increasing the concession period scenario and a combination of any two of the above scenarios. Then, the reports module presents the best scenario from the perspective of the public sector, followed by the best scenario from the perspective of the private sector, and finally the best scenario from the perspective of both.

The module presents three decision tree reports, each presenting the expected monetary value (EMV), which is another way of calculating the scenario score. The trees start with a decision node, with the four alternatives of scenarios branching from it. Each scenario has branches presenting the criteria, and each criteria branches into the sub-criteria. The branches have the weights, and the rankings are assigned at the end of the tree branches.

The reports module then develops the risk profile graphs as it shows the risks and opportunities of choosing one scenario over the other. The module produces a probability chart, which shows the effect of changing the weights of the criteria and sub-criteria on the scenario scores, reflecting the probability of choosing a certain scenario over the other. A cumulative graph is also developed, which presents the ranges of values that the scenario can yield vs the corresponding probabilities or weights. A statistical summary report is then formulated to provide some statistics about all the ranges of possible outcomes of the decision tree.

The module also develops policy suggestion reports, which help the decision maker look at the broader picture when making his decision. The decision table report provides the "benefit of correct choice," which is basically the difference between the value of the highest scenario score and the lowest one. This helps in showing whether the scenario scores are close or not. The policy suggestion reports also include an optimal tree report that shows the path of the optimal decision only.
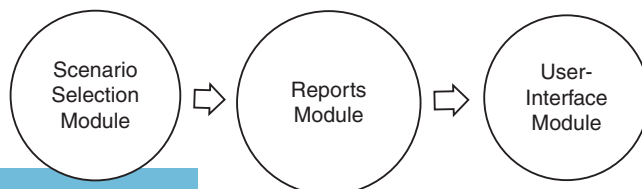

Figure 4.
The reports module interrelation with the other modules

The sensitivity analysis module
Figure 5 shows the relationship between the sensitivity analysis module and the framework modules. The sensitivity analysis module inputs come from the scenarios selection module, and it presents its outputs to the user-interface module directly. The sensitivity analysis is another form of the risk profile graphs of the reports module. It shows the effect of changing certain inputs on the final output of the module. The sensitivity analysis is performed to study the effect of changing the criteria rankings on the scenario scores.

As stated above, the inputs of the sensitivity analysis module are the ranks presented in the scenarios selection module. The criteria rankings can be any integer number between one and five. The sensitivity analysis is done by changing the value of the rankings of the sub-criteria from one to five, and the output is observed. This is done for the sub-criteria that have the highest rankings; moreover, it is performed individually for each sub-criteria, then a double-sensitivity analysis is executed to measure the effect of changing two sub-criteria at the same time. A strategy graph is also provided to measure the sensitivity of changing the rankings of a sub-criteria on all the alternatives or the scenarios to determine the area of decision within the desired output. A tornado graph and a spider graph are used to present the results of the sensitivity analysis.

Discussions and analysis
The previous framework can be applied using computer software including Microsoft Excel 2013, VBA programming language, and the Precision Tree 5.5 for Excel add-in. In order to demonstrate the application of the framework developed, data were used from a case study that represents a wastewater treatment plant which has faced a renegotiation problem due to a delay by the public sector to deliver the influent water (the wastewater to be treated by the plant), and a delay by another public institution to provide the effluent pumping station. In each of the modules, the data used shall be explained in their context.

The scenarios selection module
The purpose of the scenarios selection module is to be able to identify the best scenario from the four re-equilibrium scenarios: paying a lump sum amount to the private sector, increasing the service charge, adjusting the concession period and a fourth scenario with a combination of any two of the above scenarios. The aim is to maximize the satisfaction of both the private and the public sectors. In order to achieve this goal, a set of criteria should be defined in order to evaluate this degree of satisfaction.

After the final set of scenarios has been developed, the user shall click the button at the bottom to enter the re-equilibrium criteria. The user-interface module presents the screen in Figure 6 for the user to enter the criteria in the first row of the table. The user may also enter sub-criteria for each one of the criteria. The criteria main categories are economic, political, financial, project related, contractual and policy. The economic criteria have to do with the economic situation of the country where the project is located. The sub-criteria for this category include inflation, general conditions of the country, stability of the exchange rates and how the IRR is affected by all of the above. This is followed by the political criteria. The sub-criteria include long-term stability of the country, the current political situation and the
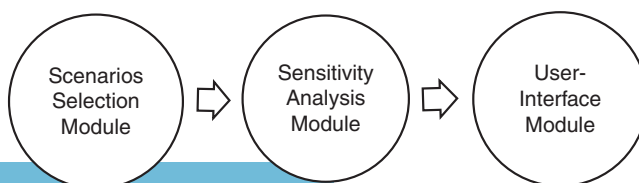

Figure 5.
The sensitivity
analysis module
interrelation with the
other modules

justice system in general. In addition, the financial criteria have to do with the party's financial standing. It includes any current financial obligations required to be paid by the party, additional financial obligations, liquidity, the ratio between debt and equity, and the transparency of financial data. On the other hand, the project-related criteria is specific to the project nature, which includes original concession period, preferable concession period and the level of complexity of the project. Moreover, the contractual criteria include existence of regulator, risk sharing agreement, and how clear the termination clauses and re-equilibrium clauses are. Finally, the policy criteria is the general manner in which a certain party usually reacts to a certain situation. It includes the long-term business strategy, the likelihood of repeated business with a certain partner who is able to recognize the claim, and the experience of other partners. After the user enters the re-equilibrium criteria, the user shall enter scenario one priorities by clicking on the button in Figure 6. The user is then directed to the screen in Figure 7.

The weights of each criteria and sub-criteria change depending on its relation to a certain scenario, as explained in the methodology; hence, the user shall be directed to four screens, each one representing the weights for a specific scenario. Figure 7 shows a sample of the priorities of the criteria and the economic sub-criteria for scenario one. The user is asked to select from a dropdown menu which is more important among combinations of two criteria with respect to the selected scenario. The user has the right to select both criteria if he believes that they are equally important. In the background of the model, this information shall be transferred to form the decision matrix shown in Figure 8. The decision matrix is a mirror matrix with the top row identical to the first column, then the priorities are entered in the respective cells. The weights of the criteria or the sub-criteria are calculated in the tables, shown also in Figure 8, by counting the number of occurrences of the criteria or the sub-criteria in the decision matrix and dividing it by the total number of occurrences of all the criteria or the sub-criteria to get a percentage. The weights for the economic, political, financial, project-related, contractual and policy with respect to scenario one are shown in Figure 8.

Figure 6.
Re-equilibrium criteria

Figure 7.
Criteria and
sub-criteria priorities

Criteria

Criteria	Economic	Political	Financial	Project Related	Contractual	Policy
Economic		Political	Financial / Economic	Economic	Contractual	Economic
Political			Financial	Project Related	Political	Political
Financial				Project Related	Financial	Financial
Project Related					Project Related	Policy / Project Related
Contractual						Policy
Policy						

Criteria	# of Occurrence	Weight
Economic	3	18%
Political	3	18%
Financial	4	24%
Project Related	4	24%
Contractual	1	6%
Policy	2	12%

Economic

Economic	Inflation	General Conditions	Exchange Rates	Effect on IRR
Inflation		General Conditions	Inflation	Inflation
General Conditions			Exchange Rates / General Conditions	General Conditions
Exchange Rates				Exchange Rates
Effect on IRR				

Economic	# of Occurrence	Weight
Inflation	2	29%
General Conditions	3	43%
Exchange Rates	2	29%
Effect on IRR	0	0%

Figure 8.
Criteria and
sub-criteria
decision matrix

After the user selects all the priorities for the four scenarios, the weights are ready to be used in the weighted sum model. As stated before, there exist separate weights for the criteria and the sub-criteria for each one of the four scenarios. However, the user is to enter only one rank for all the four. The user will be directed to the screen where he enters a ranking for the sub-criteria. A sample of the ranking sheet is shown in Figure 9. There exist two separate

Criteria	Related Risk	Risk Allocation	Rank	Rank #
Economic				
Inflation	Inflation	Primarily to Private Sector	Suitable	4
General Conditions	Influential economic events	Primarily to Private Sector	Suitable	4
Exchange Rates	Influential economic events	Solely to Private Sector	Very Suitable	5
Effect on IRR	Financial attraction of project	Solely to Private Sector		1
	Level of demanding project		Very Suitable	
	Different working methods		Suitable	
	Industrial regulatory change		Neutral	
	High financing cost		Unsuitable	
	Interest rate		Very Unsuitable	
Long-term Stability	Organization and coordination risk	Public Sector	Very Unsuitable	1
Current Political Situation	Poor political decision-making process	Public Sector	Very Unsuitable	1
Justice System	Legislation change	Shared	Very Suitable	5
Financial				
Current Financial Obligations	Lack of commitment from public/private partner	Shared	Suitable	4
Additional Financial Requirements	Financial market	Solely to Private Sector	Suitable	4
Liquidity	Availability of finance	Solely to Private Sector	Neutral	3
Ratio Debt vs. Equity	High financing cost	Solely to Private Sector	Suitable	4
Transparency	Level of public support	Strongly Depending	Very Suitable	5
Project Related				
Original Concession Period	Construction time delay	Solely to Private Sector	Suitable	4
Preferred Concession Period	Construction time delay	Solely to Private Sector	Neutral	3
Complexity of the Project	Quality of workmanship	Solely to Private Sector	Neutral	3
Contractual				
Existence of Regulator	Industrial regulatory change	Solely to Private Sector	Very Unsuitable	1
Risk Sharing Agreement	Responsibilities and risk distribution	Shared	Suitable	4
Termination Clauses	Force majeure	Shared	Suitable	4
Re-equilibrium Clauses	Contract variation	Strongly Depending	Suitable	4
Policy				
Business Strategy	Financial attraction of project	Primarily to Private Sector	Very Suitable	5
Likelihood of Repeated Business	Residual risk	Primarily to Private Sector	Neutral	3
Who Recognized the Claim	Level of public support	Strongly Depending	Neutral	3
Experienced Parties	Lack of experiences in PPP arrangement	Strongly Depending	Very Suitable	5

Input Public Sector Ranking

Figure 9.
Sub-criteria ranking

sheets for the private sector and the public sector. The sheet structure is shown in Figure 9, where the first column is the sub-criteria. In order to decide whether this sub-criteria is in favor of the party or not, the user looks at the risk allocations in order to see the broader picture. The following column is related risk, where the user chooses the risk that affects his decision from a dropdown menu. The risk allocation will automatically appear for the user to choose the suitable rank for a certain sub-criteria. The ranks are very suitable, suitable, neutral, unsuitable, and very unsuitable. The user selects the ranks from a dropdown menu. The weights and ranks are advised by governmental officials and private sector representatives.

After both the private sector and the public sector enter the ranks, twelve scenario scores are calculated: four from the public sector perspective, four from the private sector perspective, and four from the perspective of both. Using the weighted sum model presented in Equation (1), where (x) is the number of alternatives scenarios, which is 12 scenarios (i) is the number of main criteria, which is six (j) is the number of sub-criteria of a certain main criteria, which varies depending on the criteria (W) is the weights and (R) is the rankings. Figure 10 shows the calculations of the scenario scores in the bottom. The last column to the right, called the combined ranks, is the average of the private sector ranks and the public sector ranks. The scenarios with the highest scores are identified as the best scenarios for each party and the combined best scenario for both the public and the private sectors. After entering the ranks, the user is directed to the results directly without going into the calculation details. The results are presented via the user-interface screen shown in Figure 11.

The reports module

By clicking on the link at the bottom of Figure 11, the user will be directed to the reports module. The reports module includes all the outputs of the previous modules. The PPP concession value and the re-equilibrium value is also reported in this section; moreover, this section also includes

Weighted Sum Model

Criteria	Scenario 1 Weights	Scenario 2 Weights	Scenario 3 Weights	Scenario 4 Weights	Private Sector Ranks	Public Sector Ranks	Combined Ranks
Economic	18%	19%	19%	21%			
Inflation	29%	29%	14%	29%	4	5	4.5
General Conditions	43%	43%	43%	43%	4	2	3
Exchange Rates	29%	29%	29%	29%	5	2	3.5
Effect on IRR	0%	0%	14%	0%	1	1	1
Political	18%	19%	19%	16%			
Long-term Stability	67%	33%	67%	50%	1	2	1.5
Current Political Situation	0%	0%	0%	25%	1	3	2
Justice System	33%	67%	33%	25%	5	2	3.5
Financial	24%	19%	19%	21%			
Current Financial Obligations	36%	18%	36%	27%	4	4	4
Additional Financial Requirements	27%	27%	27%	27%	4	4	4
Liquidity	18%	27%	9%	27%	3	3	3
Ratio Debt vs. Equity	9%	18%	18%	9%	4	2	3
Transparency	9%	9%	9%	9%	5	4	4.5
Project Related	24%	25%	19%	21%			
Original Concession Period	50%	50%	50%	50%	4	4	4
Preferred Concession Period	25%	25%	25%	25%	3	3	3
Complexity of the Project	25%	25%	25%	25%	3	4	3.5
Contractual	6%	6%	13%	5%			
Existence of Regulator	29%	29%	29%	29%	1	4	2.5
Risk Sharing Agreement	43%	29%	43%	29%	4	2	3
Termination Clauses	14%	14%	14%	29%	4	4	4
Re-equilibrium Clauses	14%	29%	14%	14%	4	1	2.5
Policy	12%	13%	13%	16%			
Business Strategy	13%	25%	13%	25%	5	5	5
Likelihood of Repeated Business	25%	25%	25%	25%	3	3	3
Who Recognized the Claim	38%	13%	38%	38%	3	5	4
Experienced Parties	25%	38%	25%	13%	5	5	5

	Scenario 1 Score	Scenario 2 Score	Scenario 3 Score	Scenario 4 Score	Best Scenario
Private Sector	3.54	3.81	3.43	3.52	Scenario 2 with Score 3.81
Public Sector	3.28	3.20	3.07	3.36	Scenario 4 with Score 3.36
Combined	3.41	3.51	3.25	3.44	Scenario 2 with Score 3.51

Figure 10.
Scenario scores
calculations
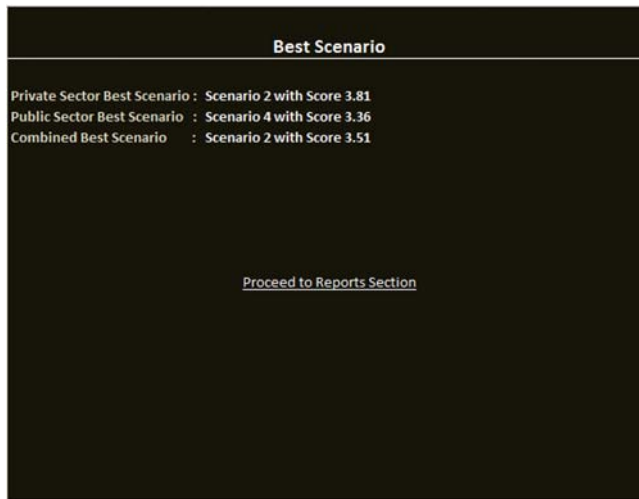
Figure 11.
DSS user-interface
No. 7

the re-equilibrium scenarios reports and the best scenarios reports. The reports module also includes the risk allocation charts. A sample of the charts is shown in Figure 12. Risk allocation charts give a sense of which party is bearing the highest share of the risks.

All the reports developed in this module are developed using Precision Tree 5.5 for Excel add-in. The following report is the decision tree showing the process of selecting the best scenario and calculating the EMV. Three trees are formulated: one for the private sector best scenario, one for the public sector best scenario and one for the best scenario considering both of them. Three more charts are drawn to show only the optimal paths of the three trees, a sample of which is shown below in Figure 13. It belongs to the private sector decision tree. As shown previously, the second scenario is the scenario with the highest score, which
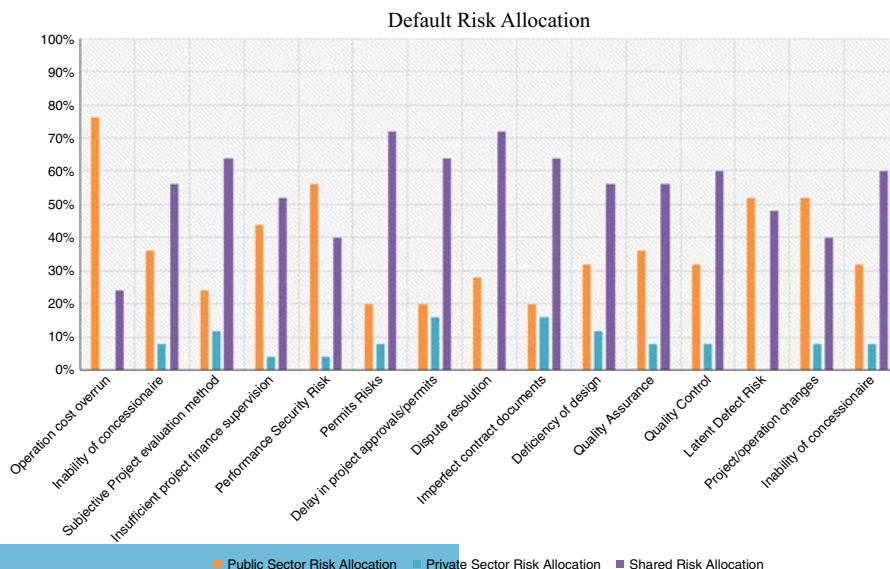
Figure 12.
Default risk
allocation chart
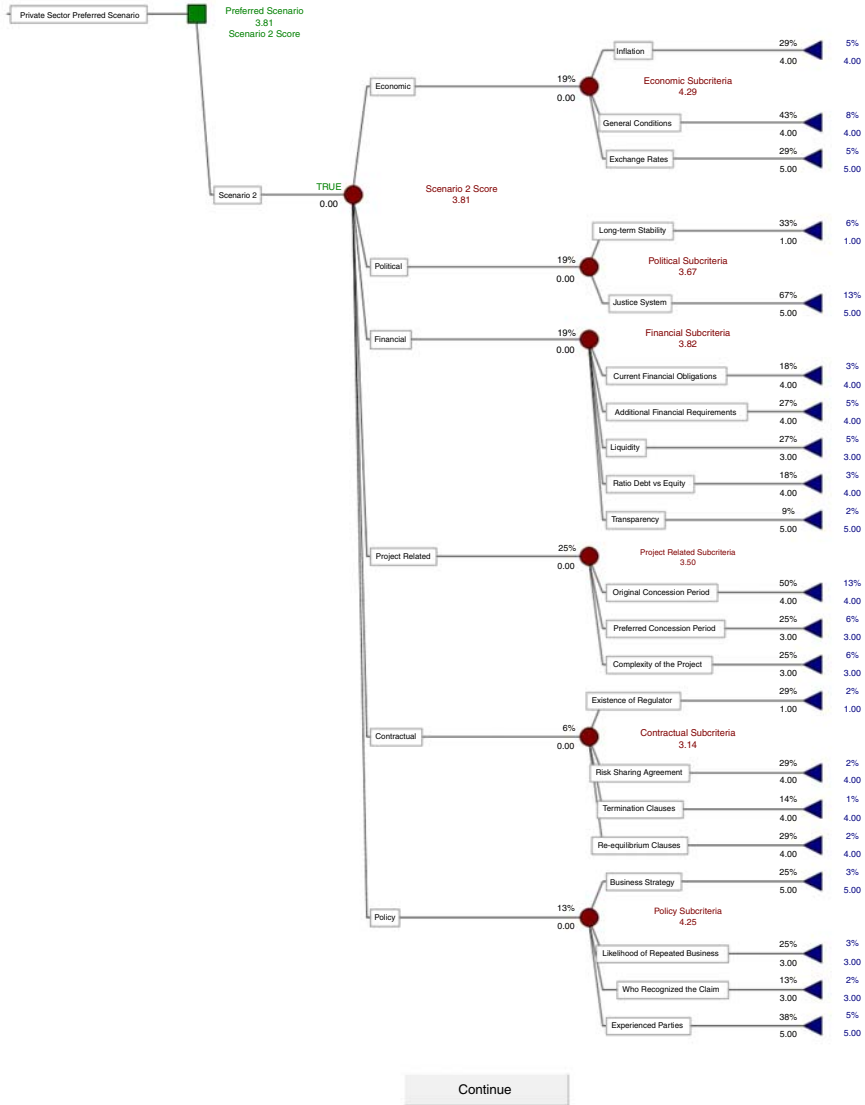
Figure 13.
Private sector
optimal decision tree

means it is the preferable scenario for the private sector. Figure 13 shows the calculations of scenario two scores, where the first decision node represents the criteria of selection and the weights are shown at the arrows. The following decision nodes represent the sub-criteria, where the arrows have both their weights and the ranks, as well.

The risk profile graphs consist of a probability chart, a cumulative graph, and a statistical summary. The purpose of these graphs is to show the risks and probability of selecting one scenario vs the other. A sample of the reports belonging to the private sector is

shown below. Figure 14 demonstrates the first type of risk profile graph, the probability chart. The chart shows the different values for the four scenario scores and their probability of occurrence. For example, the probability that the scenario one score equals four is 46 percent, and the probability that the scenario three score equals three is 19 percent.

On the other hand, Figure 15 demonstrates the cumulative probability chart, in which the chart demonstrates the probability of a scenario score equal or less than a certain value. For instance, the probability that the scenario two score is less than or equal to three is 30 percent, while the probability that the scenario four score is less than or equal to one is 13 percent.

Figure 16 displays a statistical summary of the risk profile, which includes statistical information such as the mean, the standard deviation, the minimum and maximum values, the mode, the skewness and the kurtosis. As shown in the figure, the expected value or the mean for scenario one is 3.54, for scenario two is 3.81, for scenario three is 3.43 and for scenario four is 3.52. From the expected value point of view only, scenario two is the optimum scenario to be selected by the private sector.

PrecisionTree Risk Profile - Probability Chart
Performed By: Amira Shalaby
Date: Sunday, May 25, 2014 3:30:46 PM
Model: Decision Tree "Private Sector Preferred Scenario" in [Decision Support System v26.xlsm] Decision Tree (EMV) - Pr
Analysis: Choice Comparison for Node "Preferred Scenario" (C66)

Probabilities for Decision Tree "Private Sector Preferred Scenario"
Choice Comparison for Node "Preferred Scenario"

Chart Data

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Value	Probability	Value	Probability	Value	Probability	Value	Probability
#1	1.00	13%	1.00	8%	1.00	19%	1.00	13%
#2	3.00	23%	3.00	22%	3.00	19%	3.00	26%
#3	4.00	46%	4.00	42%	4.00	44%	4.00	43%
#4	5.00	17%	5.00	27%	5.00	18%	5.00	18%

Continue

Figure 14.
Private sector
probability chart

PrecisionTree RiskProfile - Cumulative Chart
Performed By: Amira Shalaby
Date: Sunday, May 25, 2014 3:30:48 PM
Model: Decision Tree "Private Sector Preferred Scenario" in [Decision Support System v26.xlsm] Decision Tree (EMV) - Pr
Analysis: Choice Comparison for Node "Preferred Scenario" (C66)

Cumulative Probabilities for Decision Tree "Private Sector Preferred Scenario"
Choice Comparison for Node "Preferred Scenario"

Chart Data

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Value	Probability	Value	Probability	Value	Probability	Value	Probability
#1	−Infinity	0%	−Infinity	0%	−Infinity	0%	−Infinity	0%
#2	1.00	0%	1.00	0%	1.00	0%	1.00	0%
#3	1.00	13%	1.00	8%	1.00	19%	1.00	13%
#4	3.00	13%	3.00	8%	3.00	19%	3.00	13%
#5	3.00	37%	3.00	30%	3.00	38%	3.00	39%
#6	4.00	37%	4.00	30%	4.00	38%	4.00	39%
#7	4.00	83%	4.00	73%	4.00	82%	4.00	82%
#8	5.00	83%	5.00	73%	5.00	82%	5.00	82%
#9	5.00	100%	5.00	100%	5.00	100%	5.00	100%
#10	Infinity	100%	Infinity	100%	Infinity	100%	Infinity	100%

Continue

Figure 15.
Private sector
cumulative chart

PrecisionTree Risk Profile - Statistical Summary
Performed By: Amira Shalaby
Date: Sunday, May 25, 2014 3:30:48 PM
Model: Decision Tree "Private Sector Preferred Scenario" in [Decision Support System v26.xlsm] Decision Tree (EMV) - Pr
Analysis: Choice Comparison for Node "Preferred Scenario" (C66)

Statistics	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Mean	3.54	3.81	3.43	3.52
Minimum	1.00	1.00	1.00	1.00
Maximum	5.00	5.00	5.00	5.00
Mode	4.00	4.00	4.00	4.00
Std. Deviation	1.19	1.09	1.32	1.19
Skewness	−0.9855	−1.1150	−0.8436	−0.9187
Kurtosis	−3.2499	4.0348	2.5643	3.1620

Continue

1018

Figure 16.
Private sector
statistical summary

Figure 17 displays another type of reports called the policy suggestion reports. Those reports help the management see the broader picture, not only the scenario with the highest score. The decision trees and the optimal decision tree in Figure 13 are considered part of this section of reports. Figure 17 shows optimal decision selected at each decision node and what is called "benefit of the correct choice." Since the model has only one decision node, which is selecting the best scenario, the table has only one decision node, and its probability of occurrence is 100 percent. The benefit of the correct choice is the difference between the highest scenario score and the l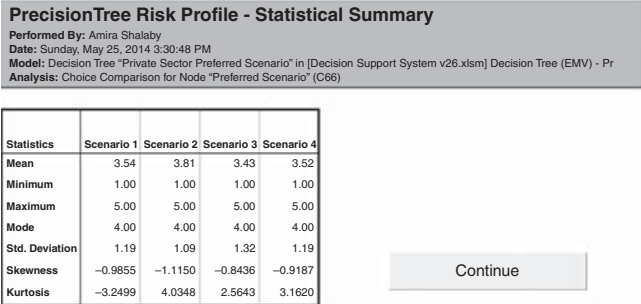owest scenario score. In the case of the private sector, the highest scenario score is a scenario two score which equals 3.81, and the lowest scenario score is scenario three which equals 3.43. The difference between the two scenarios is 0.38, which is the benefit of the correct choice in Figure 17. This helps the management get a sense of the whole spectrum when making their decision.

The sensitivity analysis module
The sensitivity analysis module is the final module in the decision support system. The sensitivity analysis is applied to the ranks of the sub-criteria. As the ranks change from very suitable, which is denoted by the number five, to very unsuitable, which is denoted by the number one, the scenario scores are affected. Hence, it is important to observe how sensitive the scenario scores are to the change in the rank of a certain sub-criteria. The sub-criteria with the highest ranks are chosen for the sensitivity analysis; moreover, double sensitivity analysis is also performed to study the effect of changing two sub-criteria ranks at the same time. A sample of the sensitivity analysis reports is presented below.

The sensitivity graph in Figure 18 shows the relationship between changing the ranking of the "exchange rates" sub-criteria and the EMV of the tree. The table on the right shows that if the ranking decreased by 80 percent, the EMV would decrease by almost six percent. In addition, if the ranking decreased by 20 percent, the EMV would decrease by almost one percent. The difference between the highest EMV and the lowest EMV is 0.21, more than half the "benefit of correct choice" value, which denotes that the change of ranking of the "exchange rates" sub-criteria is rather sensitive to the selection of the best scenario process.

PrecisionTree Policy Suggestion - Decision Table
Performed By: Amira Shalaby
Date: Sunday, May 25, 2014 3:42:36 PM
Model: Decision Tree "Private Sector Preferred Scenario" in [Decision Support System v26.xlsm] Decision Tree (EMV) - Pr

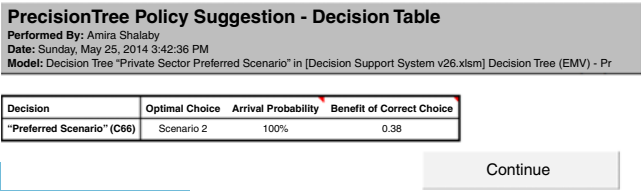| Decision	Optimal Choice	Arrival Probability	Benefit of Correct Choice
"Preferred Scenario" (C66)	Scenario 2	100%	0.38

Continue

Figure 17.
Private sector
policy suggestion

PrecisionTree Sensitivity Analysis - Sensitivity Graph
Performed By: Amira Shalaby
Date: Sunday, May 25, 2014 5:40:50 PM
Output: Decision Tree "Private Sector Preferred Scenario" (Expected Value of Entire Model)
Input: Branch Value "Exchange Rates" of Node 'Economic Su (E12)

Sensitivity of Decision Tree "Private Sector Preferred Scenario"
Expected Value of Node "Preferred Scenario" (C66)
With Variation of Branch Value "Exchange Rates" of Node 'Economic Su (E12)
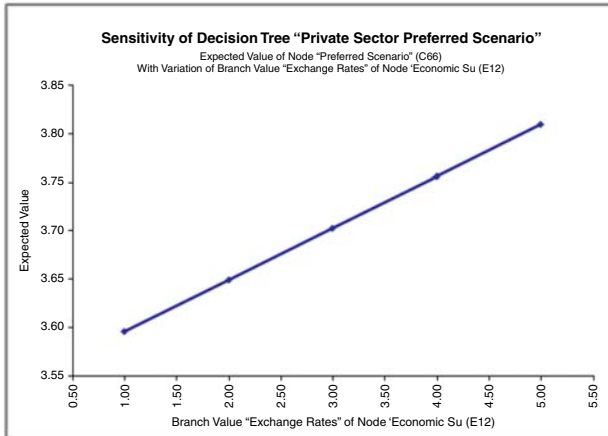
	Sensitivity Data			
	Input		**Output**	
	Value	Change (%)	Value	Change (%)
#1	1.00	−80.00%	3.60	−5.62%
#2	2.00	−60.00%	3.65	−4.22%
#3	3.00	−40.00%	3.70	−2.81%
#4	4.00	−20.00%	3.76	−1.41%
#5	5.00	0.00%	3.81	0.00%

Continue

Figure 18.
"Exchange rate"
sub-criteria rank
sensitivity graph

Figure 19 is the second type of sensitivity report: the strategy region report. The strategy region report shows how sensitive each scenario score is to the change in the ranking of the "exchange rate" sub-criteria. The figure shows that for every possible value of the ranking of the "exchange rate" sub-criteria, scenario two shall always have the highest EMV. In other words, the result is not sensitive at all to the value of this variable. However, each scenario score is affected differently by the change of the ranking of this factor. For instance, the scenario four score is more sensitive to changing the ranking than the scenario one score,

PrecisionTree Sensitivity Analysis - Strategy Region
Performed By: Amira Shalaby
Date: Sunday, May 25, 2014 5:40:51 PM
Output: Decision Tree "Private Sector Preferred Scenario" (Expected Value of Entire Model)
Input: Branch Value "Exchange Rates" of Node 'Economic Su (E12)

Strategy Region of Decision Tree "Private Sector Preferred Scenario"
Expected Value of Node "Preferred Scenario" (C66)
With Variation of Branch Value "Exchange Rates" of Node 'Economic Su (E12)

Scenario 1
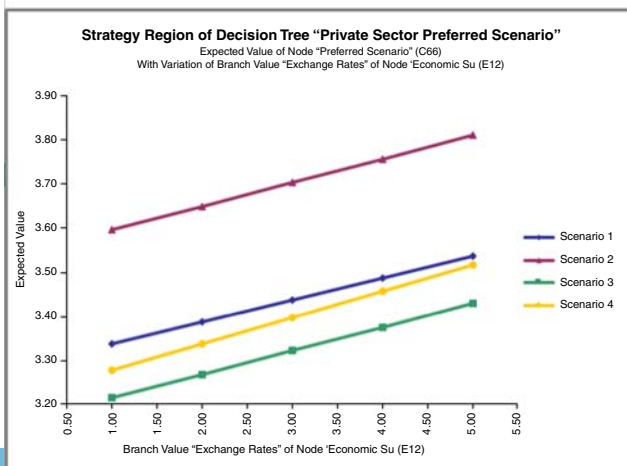Scenario 2
Scenario 3
Scenario 4

Figure 19.
"Exchange rate"
sub-criteria rank
strategy region

as the line is steeper. Figure 20 shows the three sub-criteria: "long-term stability," "exchange rates," and "inflation." The graph shows the EMV corresponding to each sub-criteria when its ranking varies from one to five. The first bar on the top is the "long term stability" sub-criteria. This bar is noticed to be the longest bar among the three, which shows that the EMV is more sensitive to the change of the ranking than the other sub-criteria.

The spider graph shown in Figure 21 confirms the same conclusion, as the line of the "long-term stability" sub-criteria is steeper than the other two lines, followed by the line of

PrecisionTree Sensitivity Analysis - Tornado Graph
Performed By: Amira Shalaby
Date: Sunday, May 25, 2014 5:40:51 PM
Output: Decision Tree "Private Sector Preferred Scenario" (Expected Value of Entire Model)

Tornado Graph of Decision Tree "Private Sector Preferred Scenario"
Expected Value of Entire Model

Branch Value "Long-term Stability" of Node 'Politi (E18)

Branch Value "Exchange Rates" of Node 'Economic Su(E12)

Branch Value "Inflation" of Node 'Economic Subcrit (E6)

Expected Value

Figure 20.
Private sector
Tornado graph

PrecisionTree Sensitivity Analysis - Spider Graph
Performed By: Amira Shalaby
Date: Sunday, May 25, 2014 5:40:52 PM
Output: Decision Tree "Private Sector Preferred Scenario" (Expected Value of Entire Model)

Spider Graph of Decision Tree "Private Sector Preferred Scenario"
Expected Value of Entire Model

Expected Value

Change in Input (%)

Branch Value "Long-term Stability" of Node 'Politi (E18)

Branch Value "Exchange Rates" of Node 'Economic Su (E12)

Branch Value "Inflation" of Node 'Economic Subcrit (E6)
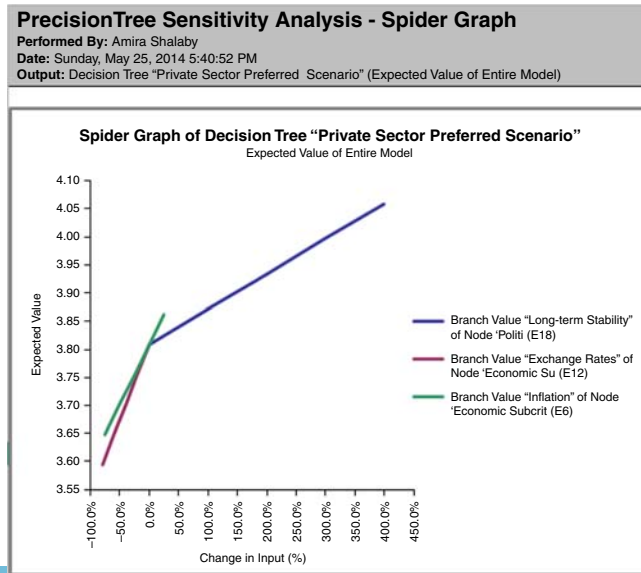
Figure 21.
Private sector
spider graph

the "exchange rates" sub-criteria and in the end the line of the "inflation" sub-criteria. This concludes that the "long-term stability" is highly affected by the change in the ranks followed by the "exchange rates" sub-criteria and the "inflation" sub-criteria.

A two way sensitivity analysis is also performed to study the effect of changing the ranking of two sub-criteria at the same time on the EMV of the decision tree or the preferred scenario. The two sub-criteria with the highest weights are selected, which are the "justice system" and the "long-term stability." Figure 22 shows the sensitivity graph for both sub-criteria with respect to the private sector EMV. The x-axis denotes the ranking of the "long-term stability" sub-criteria, the y-axis denotes the "justice system" sub-criteria, and finally, the z-axis denotes the EMV of the model. As shown in the figure and the attached table, as the rankings of the "justice system" sub-criteria and the "long-term stability" sub-criteria increase, the EMV increases, as well.

Another type of two way sensitivity analysis is the strategy region. Figure 23 shows the strategy region of the "justice system" sub-criteria and the "long term stability" sub-criteria for the private sector decision tree. The strategy region graph aims to provide the user with every possible outcome for every combination of the sub-criteria rankings.

For any combination of the rankings of the two sub-criteria, two possible preferred scenarios exist: either scenario one or scenario two. The probability of obtaining scenario one is higher than scenario two, as there exist a larger number of combinations resulting in scenario one than the number of combinations resulting in scenario two. It is also noticed from the graph that when the ranking of "justice system" sub-criteria approaches the maximum value and the ranking of the "long-term stability" sub-criteria approaches the minimum, scenario two becomes the optimum scenario and vice versa.
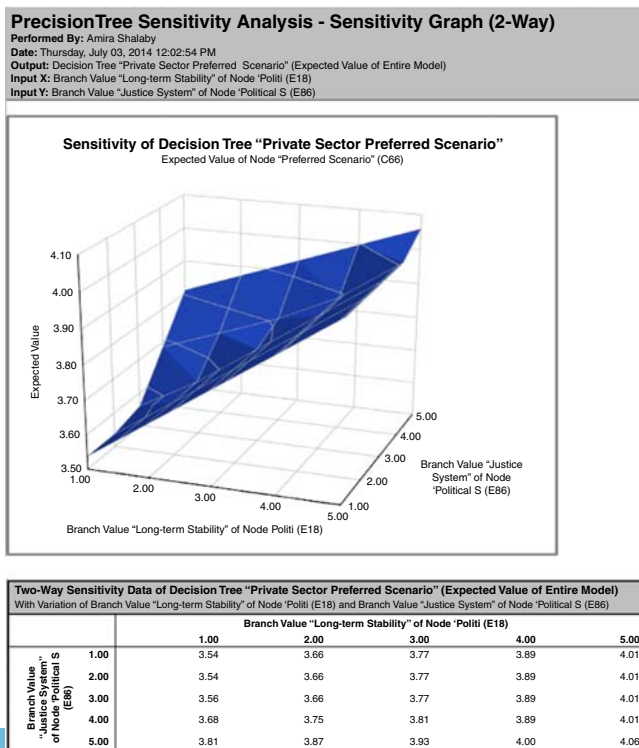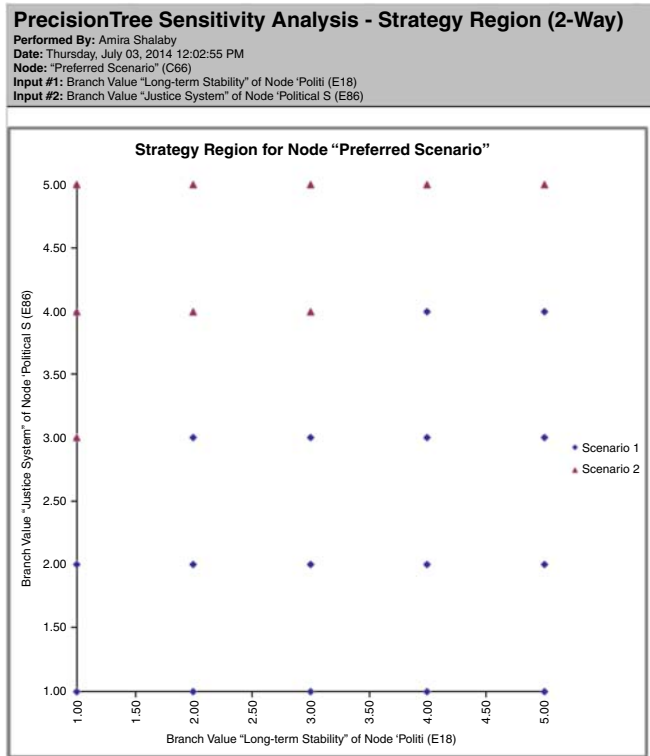

PrecisionTree Sensitivity Analysis - Sensitivity Graph (2-Way)
Performed By: Amira Shalaby
Date: Thursday, July 03, 2014 12:02:54 PM
Output: Decision Tree "Private Sector Preferred Scenario" (Expected Value of Entire Model)
Input X: Branch Value "Long-term Stability" of Node 'Politi (E18)
Input Y: Branch Value "Justice System" of Node 'Political S (E86)

Sensitivity of Decision Tree "Private Sector Preferred Scenario"
Expected Value of Node "Preferred Scenario" (C66)

Two-Way Sensitivity Data of Decision Tree "Private Sector Preferred Scenario" (Expected Value of Entire Model)
With Variation of Branch Value "Long-term Stability" of Node 'Politi (E18) and Branch Value "Justice System" of Node 'Political S (E86)

		Branch Value "Long-term Stability" of Node 'Politi (E18)				
		1.00	2.00	3.00	4.00	5.00
Branch Value "Justice System" of Node 'Political S (E86)	1.00	3.54	3.66	3.77	3.89	4.01
	2.00	3.54	3.66	3.77	3.89	4.01
	3.00	3.56	3.66	3.77	3.89	4.01
	4.00	3.68	3.75	3.81	3.89	4.01
	5.00	3.81	3.87	3.93	4.00	4.06

Figure 22.
Two way sensitivity graph

PrecisionTree Sensitivity Analysis - Strategy Region (2-Way)
Performed By: Amira Shalaby
Date: Thursday, July 03, 2014 12:02:55 PM
Node: "Preferred Scenario" (C66)
Input #1: Branch Value "Long-term Stability" of Node 'Politi (E18)
Input #2: Branch Value "Justice System" of Node 'Political S (E86)

Strategy Region for Node "Preferred Scenario"

Figure 23.
Two way
sensitivity analysis
strategy region

Conclusion

The purpose of this research is to develop a tool which will assist the re-equilibrium process of the financial model of PPP contract. Re-equilibrium is the process of adjusting the cash flow of the PPP project to return the rate of return of the private sector to the original rate of return at the contract commencement. Contract renegotiation at this stage is necessary to protect the rights of the different stakeholders of the project. The model is developed using Microsoft Excel 2013, VBA programming language, and the Precision Tree 5.5 for Excel add-in.

The main contribution of this research is that it develops a framework that facilitates the PPP contract renegotiation process. The methodological framework is applied as a decision support system prototype model. The purpose of the suggested framework is to enable all contract stakeholders to agree on a unified method of developing the different re-equilibrium scenarios and choosing the optimal scenario that suits all parties. This will facilitate the PPP renegotiation process, which will, in turn, encourage investors to enter PPP projects. The developed framework is of great benefit to project stakeholders, including the private sector, the public sector and the users of the service. It saves time and money invested in lengthy negotiations, and it enforces transparency and mutual trust between the different parties by providing a tool that significantly minimizes conflicts during the renegotiation process and defines clear steps to be followed in order to reach an agreement that will maximize the benefits for both the private and the public sectors.

The above research has been validated via a case study, the details of which has been presented in the Ninth International Structural Engineering and Construction Conference last year (Shalaby and Hassanein, 2017).

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