Performance management using Influence Diagrams: The case of improving procurement

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Abstract

Performance management is the next step after an organization's level of performance is measured. By observing the results of performance measurement, an organization is able to see where it stands regarding its operations and performance. In this paper, a Decision Support Network is introduced for effective procurement performance management and improvement. The procurement process involves many contributing Key Performance Indicators (KPIs) which determine the procurement performance. The focus of this paper is mostly on performance management. Any organization seeks further improvements in its operations. Hence, they proceed with making decisions which they hope might increase their credibility. Yet still the implications of such decisions are to be studied so that the organization can make such decisions with more confidence, by knowing the expected impact in advance. Once the model is built, it could be used for analyzing and foreseeing the result of any kind of decision in the organization. The fundamentals of Bayesian Networks are used to build the Decision Network (DN). This DN is built for procurement performance management in particular and an application of it is demonstrated through the ending of the paper.

Keywords
Performance management, Decision analysis, Influence Diagrams, Procurement

1. Introduction and motivation

Procurement constitutes a high volume of costs and monetary turnover in any organization and hence is at significant importance to the organization (Abdollahi et al., 2015; Nair et al., 2015). Therefore it is vital to track and monitor procurement practices in an organization. It has been mentioned in the literature that better procurement practices can lead to huge savings in terms of costs and can secure a competitive edge in the market. The task of monitoring and improving the procurement process is facilitated through procurement performance measurement (Abolbashari et al., 2017) and procurement performance management (Abolbashari et al., 2018). These two complementary stages enable the organization to not only evaluate their current procurement practices, but to also manage it in an effective way. In fact, the design and implementation of a Procurement Performance Measurement System (PPMS) is the means towards achieving procurement excellence (Pohl and Forstl, 2011).
Performance measurement is the predecessor of any other action after that seeking improvement. Through performance measurement, an organization can evaluate its current performance. However, the goal is not just to see what happens when we take a certain action, but to what action we should take to reach an outcome which is favorable. The former is introduced as performance measurement where the latter falls into the category of performance management. The implication of decisions is mapped by performance measurement. The optimum decision, however, is determined by performance management where we reverse the process. In the latter, the output of each decision is foreseen and the best decision which returns the most utility is selected as the optimum decision. Figure 1 captures the two concepts of performance measurement and performance management in terms of their components and how they work. In this figure, the implications of the current decisions/practices are mapped

through performance measurement. In the revers cycle, the decision theory aims the decision maker to select the optimum decision among alternatives.

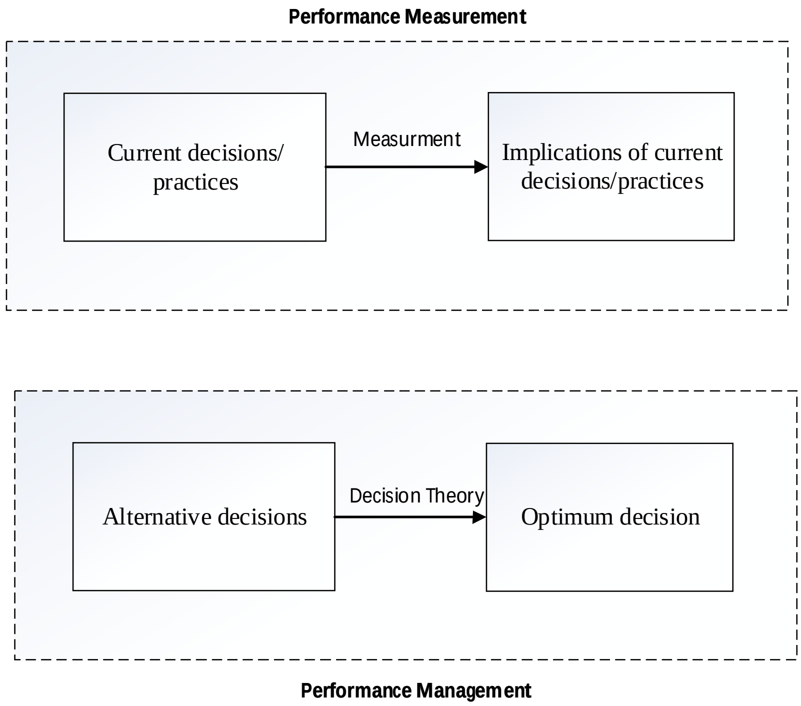

Figure 1. Performance measurement vs performance management

This paper presents the novel application of Influence Diagrams for performance management. In the literature of decision theory, many techniques have been used to determine the optimum decision which returns the most utility. One of these methods is Influence Diagrams (IDs). IDs are capable in capturing the complexities and uncertainties in challenging problems, such as the procurement process. In aiming to manage/improve the procurement process, the department in charge must deal with a complex decision-making situation. Each aspect of the procurement performance is measured through a Key Performance Indicator (KPI). Examples of such KPIs include: Procurement cycle time, Supplier performance, etc. These KPIs later integrate, combine and map the overall output which is the performance level. In attempting to improve the process, the decision maker should decide which KPI(s) to focus on, among a series of alternatives. In this paper, a novel decision making approach is proposed to facilitate the decision making process in procurement management. The methodology used for this approach is an Influence Diagram (ID). An ID is a generalized Bayesian Network which also includes Decision (Action) nodes and Utility nodes in addition to Chance nodes. These nodes are connected to each other with edges. The edges that come into Decision nodes are information edges which represent the information available to the decision maker at the time of making a decision. The edges that come into chance nodes and utility nodes are conditional edges and represent conditional relationship between the predecessor and successor. A detailed discussion on Influence Diagrams and their features has been provided by (Shachter, 1986) and (Howard and Matheson, 2005). A simple ID has been illustrated in Figure 2 where *I* is a chance node, *D* is a decision node and *U* is a utility node. In this network, the chance node *I* represents the impact level a KPI has on the overall procurement performance level. *D* is the decision on whether to invest on a KPI or not and *U* returns the utility which depends simultaneously on the impact level of a KPI and the relative decision which has been decided regarding that KPI.

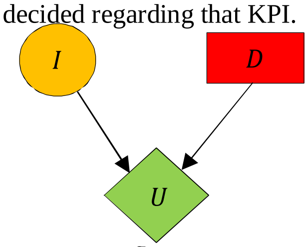

Figure 2. An Influence Diagram

In the next section, the general modelling process will be explained.

2. Modelling approach

The research question here is if an organization is to invest more on its procurement practices to achieve improvement, which KPI(s) should it invest on? In this paper, an Influence Diagram as a utility based decision network is proposed to find the optimum recommendation. According to Figure 2, the modelling features are as follows:

Notations:

$D: Decision\ node$

$U: Utility\ node$

$I: Influence\ node$

$D_i^k\ = The\ decision\ on\ whether\ to\ invest\ on\ KPI_i\ or\ not$

$I_i^j\ = Impact\ j\ of\ KPI_i\ on\ procurment\ performance\ level$

$U_i\ = The\ utillity\ associated\ with\ I_i\ and\ \ D_i^k$

$i\ = number\ of\ KPIs, utilities\ and\ decision\ nodes$

$j\ = number\ of\ states\ in\ KPI_i$

$k\ = number\ of\ possible\ decisions\ within\ each\ decision$

The probability distribution for the impact of KPI_i is as Table 1. $P(I_i^j)$ is the probability that KPI_i has the impact j. Since it is inaccurate to consider a certain value for the impact level of a KPI on the overall performance level due to the challenging task of measuring and assigning such a value, a better representation for this impact level can be expressed in the form of a probabilistic distribution. Table 1 demonstrates such a representation. In this table, a probability value ($0 \leq P(I_i^j) \leq 1$) is assigned to each impact level (I_i^j) where $\sum_1^j P(I_i^j) = 1$.

Table 1. The probability distribution defining impact levels of a KPI

I_i^1	$\cdots$	I_i^j
$P(I_i^1)$	$\cdots$	$P(I_i^j)$

The utility node has a Conditional Probability Distribution (CPD) assigned to it. This CPD depends simultaneously on the influence node and decision node as represented in Table 2. In this table, $U(I_i^j, D_i^k)$ is the utility obtained from decision k while influence j has occurred for KPI_i.

Table 2. The utility associated with a decision and a state of a KPI

	D_i^1	$\cdots$	D_i^k
I_i^1			
$\cdots$		$U(I_i^j, D_i^k)$	
I_i^j			

Accordingly, the expected utility (EU) for KPI_i when decision k has been made, can be obtained from:

$$EU(D_i^k) = \sum_j P(I_i^j)\, U(I_i^j, D_i^k) \qquad \text{Eq. 1}$$

The above formula calculates the expected utility for each decision k in KPI_i. These values should then be compared and the decision which returns the maximum expected utility should be selected.

In order to develop a decision making model for an organization's procurement practices, we should follow the following steps.

Step 1: Each organization has its own factors (attributes) for measuring performance. In the first step, the organization has to translate it's attributes into a series of KPIs. These KPIs are the chance nodes of the Influence Diagram.
Step 2: In this step we construct an ID for the organization. This ID includes chance nodes (KPIs), Decision nodes and value nodes. The model can include one or more value nodes. If we have more than one value node, then we will have a decomposed utility function. However in the example provided in this paper, we will assume only one value (utility) node and the application of considering multiple utility nodes can be studied as future research. In the ID developed at this stage, the directions of the edges are based on experts' opinions.
Step 3: Once a basic model has been developed, in step 3 the states of each node has to be defined. This information is also provided by the organization's experts.
Step 4: The ID can now be used for optimum decision making. Based on the decision making scenario, the value of the nodes are inserted.
In the next section, a numerical example will be applied to demonstrate the functionality of the proposed framework.

3. Case Study

In this section, the functionality of the proposed framework will be demonstrated using a real-world case study. We will not discuss here the reason behind what KPIs to consider or not; as this decision is case-specific and depends on the organization's overall strategy. For instance, in an organization with sustainability focus, KPIs such as sustainable procurement and solicitation might be the key focused KPIs that define procurement proficiency; whereas in an organization where the aim is competitiveness, KPIs such as emergency procurement and procurement cycle time are more desirable and will estimate the procurement proficiency level.
In 2013, USAID published a series of procurement performance indicators to be considered by procurement managers. These performance indicators are used for monitoring and improving the procurement performance (Snow, 2013). We will choose three indicators to apply in our model: Staff training, Procurement cycle time and Supplier performance. These KPIs do not necessarily have the same impact on the organization's overall procurement performance. For each KPI, we assume three different levels of impact they can possibly have on the overall procurement performance as Low, Average and High. To see what level of impact each KPI has, a questionnaire can be spread among procurement staff and managers. In this questionnaire, the participants are asked to assign a probability distribution to a KPI's impact level, based on their own understanding and expertise. These opinions will then be aggregated and a final probability distribution will be considered for each KPI's impact level. Presenting the impact level of a KPI with a probability distribution is not only not inaccurate, but is even more suitable due to the fuzzy nature of these KPIs and the existing difficulty associated with measuring them. Moreover, since opinions might be slightly different on the impact level each KPI has, the best way to express the results would be in the form of probabilistic distributions. After gathering and combining the required data, the probability distribution of the impact level each KPI has are shown in Table 3.

Table 3. Probability distributions for the impact of each KPI

KPI	**Impact level**		
	Low	Average	High
Staff training	0.3	0.5	0.2
Procurement cycle time	0.8	0.1	0.1
Supplier performance	0.4	0.2	0.4

The results in Table 3 can be interpreted as follows. 30 percent of the respondents to the questionnaire believed "Staff training" has low impact on the overall procurement performance level, while 50 and 20 percent of the respondents believed the same KPI has average and high impact on the overall procurement performance level respectively. In this scenario, we want to determine whether the organization should invest on the improvement of a KPI or not. In other words, what will be the best decision (invest/not invest) for each KPI, which returns the maximum utility? In this case, each KPI can be assigned an ID as in Figure 2. The acquired utility from each decision regarding each KPI on a scale from -10 to 10 is elicited from the experts within the organization and expressed in Tables 4 to 6. Note that the utility acquired from each decision regarding a KPI is dependent to the impact that KPI has on the overall procurement performance level.

Table 4. Utility values for KPI_1: Staff training

	Decision: Invest	
Impact level	Yes	No
Low	-5	1
Average	4	-2
High	10	-4

Table 5. Utility values for KPI_2: Procurement cycle time

	Decision: Invest	
Impact level	Yes	No
Low	-4	2
Average	3	-2
High	9	-3

Table 6. Utility values for KPI_3: Supplier performance

	Decision: Invest	
Impact level	Yes	No
Low	-10	3
Average	3	-2
High	6	-4

Finally, the expected utility for each decision can be calculated from Eq. 1. As follows:

and results followed by the chosen optimum decision are listed in Table 7.

Table 7. Expected utilities

Decision	**Expected utility**	**Optimum decision**
(D_1^1)	2.5	D_1^1
(D_1^2)	-1.5	
(D_2^1)	8.8	D_2^1
(D_2^2)	-3.4	
(D_3^1)	-1	D_3^2
(D_3^2)	-0.8	

According to the results in Table 7, the optimum decision is to invest on Staff training and Procurement cycle time but not to invest on Supplier performance.

4. Conclusion

The focus of this paper is on performance management using Influence Diagrams, followed by its application in the field of procurement. Once the performance level in an organization is measured, the organization will have an understanding on how well its operations are. The step after that is to undertake effective actions (performance management) to maintain a good level of performance or to improve a poor one. The level of procurement performance is levered by the amount of resources[1] spent on it. One strategy to improve procurement performance is to make better use of the current available resources, spent for maintaining procurement proficiency level. In this strategy, the resources are re-allocated among the KPIs in which the more important KPIs, receive a higher volume of resources and vice versa (Abolbashari *et al.*, 2018). Alternatively, an organization might be willing to spend more resources to improve procurement performance. The latter is studied in this paper and an Influence Diagram is used for determining the optimum decision.

5. Future research

Apart from the scenario illustrated in this paper, two more scenarios can be studied for future work. The first scenario is when only one KPI needs to be selected for the organization to focus on. The application of such a scenario is for some organizations that are willing to have a single strategy as their core competitive advantage. In this case, all KPIs need to be compared against a single utility function and the KPI which returns the most expected utility should be chosen. The second scenario is when a limited amount of resources is available. In this case, considering the optimum decision regarding each KPI might exceed the resource cap. This case is similar to distributing a constant value of resources among a portfolio of KPIs. In such a case, a portfolio of KPIs with a fraction level of investment for each need to be selected for improvement, conditioned to the resource cap is not exceeded. Moreover in this case, a decision regarding a KPI affects the decision that could be made regarding other KPIs. The challenge to deal with here is a combined ID in which all the KPIs are present where a decision regarding each KPI is considered simultaneously with the decisions on the other KPIs.

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[1] Different resources include money, human, time, etc., which could all be transformed, integrated and combined into monetary values.

Biographies

Mohammad Hassan Abolbashari is a PhD student at UNSW Canberra. He received his Bachelor's and Master's degrees in Industrial Engineering from Ferdowsi University of Mashhad and Amirkabir University of Technology respectively. His research interests include the application of Bayesian Networks, Influence Diagrams and Dynamic Bayesian Networks in performance measurement and management.

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