Using System Dynamics for Predicting an Organization's Procurement Performance

M. H. Abolbashari, A. Zakeri, E. Chang

Using System Dynamics for predicting an organization's procurement performance

M.H. Abolbashari[1], A. Zakeri[1], E. Chang[1]

[1] School of Business, University of New South Wales, Canberra, Australia
{m.abolbashari,a.zakeri,e.chang}@unsw.edu.au

ABSTRACT. Procurement is one of the most important operations in any organization. To effectively manage this process, it is vital for the organization to measure and monitor its procurement performance. Not only measuring, but also managing and predicting the procurement performance can secure the organization a competitive edge in the market. In this paper, we propose a System Dynamics model for measuring, managing and predicting the procurement performance. Appropriate Key Performance Indicators of the procurement process have been selected as the variables of the model based on the literature of procurement performance measurement and also domain experts' opinions. The model is then validated and some directions for future research have been discussed.

KEYWORDS: Predictive analytics, procurement, performance prediction, System Dynamics, KPIs

1 Introduction

Performance measurement is an on-going important task in any business or organization. Companies measure performance for various reasons. The results of performance measurement are used to see how the company has met its strategic goals and how well it's performing compared to competitors. The results are also used for strategic planning for the future and modifying current strategies where necessary. Individual or group performances are also measured for monitoring staff/departments and used for promotions and awards. Not only performance measurement, but performance management and performance prediction are also useful for organizations. By performance management, a company deals with maintaining an acceptable level of performance through time; whereas by performance prediction, a company is able to foresee the future it's heading to, and if that future is not desirable, implementing corrective operations. On the other hand, one business process which is significant to each company is the procurement process. Procurement encounters 30-70% of the costs in some organizations (Nair et al. 2015) and is also a key strategic tool (Abdollahi et al. 2015). Therefore it is important to measure and monitor performance in the procurement process. The literature emphasizes that this important process hasn't received the attention it deserves in terms of studying, improvement and analysis and

despite the different research conducted in this area so far, yet there is still evidence of in-efficiencies in this process (Balter 2011; Waldron 2008). In this paper, we tackle this issue by proposing the Smart Buyer concept. We define a Smart Buyer as a buyer who is competent in the procurement process. To achieve competency in this process, the buyer should measure its procurement performance in order to have a clear understanding of its current performance, manage its procurement performance to maintain an acceptable level of performance through time, and predict its procurement performance to apply corrective strategies in case the foreseen future is undesirable. Hence we define a smart buyer as a buyer capable of procurement performance measurement, procurement performance management and procurement performance prediction. Conducting these three strategies can lead the company to procurement excellence. In this paper, we introduce such a performance measurement, management and prediction (MMP) model using System Dynamics modelling. System Dynamics can be used to study the behaviour of complex systems. The procurement process should also be studied as a complex system. When studying the procurement process in terms of measuring its performance, there are many associated Key Performance Indictors (KPIs) which have interdependencies and causal relationships between them as well. The performance MMP system should be treated as a complex system for two reasons. First and foremost, there are too many factors associated with this process which need to be considered. Secondly, the casual relationships among these factors increase the complexity of the system. One of the best modelling techniques which is capable of capturing such features is Systems Dynamic modelling. It can handle as many as factors the user desires, while it can also consider the interdependencies among the factors. These two are the modelling competencies of System Dynamics. Moreover, it has some advantages from the end-user's point of view. SD represents a visual demonstration of complex systems which has been used by many professional and even non-professional users to understand and study such systems. In addition to this user-friendly representation, it is capable of considering the quality of relationships among factors, in terms of mathematical functions, enabling the user to conduct an in-depth study and analysis of the system's behaviour.

2 System Dynamics modelling for predicting the performance of the procurement process

The first step to model the procurement process using Systems Dynamic is to identify the variables which need to be considered in the model. Since the model will be used for measuring the performance of the procurement process, these variables need to be the KPIs of the procurement process. In this section we conduct a thorough analysis of the KPIs related to the procurement process. These KPIs have been collected from an in-depth review of the literature. Afterwards, we will choose the best set of KPIs based on domain experts' opinions. Table 1 shows some previous research and the KPIs they have used as representative factors of the procurement process.

Table 1. Procurement KPIs

Paper	KPIs considered
(Hovius 2016)	Order processing time, Use of top suppliers, Solving price differences, Emergency deliveries
(Saad et al. 2016)	Suppler selection, Emergency procurement, Energy consumption, waste/toxic emission, Payment processing and time, procurement cycle time, Transparent tendering, transparent price information, Customer feedback, Cost, Supplier relationship, Staff training, E-procurement, Expiration management, Accuracy in forecasting, Efficiency, Effectiveness
(Patrucco et al. 2016)	Sustainability, Time, Cost, Quality
(Luzzini & Ronchi 2016)	Portfolio approach development, Centralised purchasing decisions, Sustainable purchasing, Purchasing report level, Supplier development and integration,
(Billow 2014)	Value for money
(Pohl & Forstl 2011)	Average time of processing a purchasing request, Price level competitiveness, Sustainable purchasing processes, CO2 emissions, Environmental performance, Internal customer satisfaction, Maverick- buying ratio, Transparent purchasing processes, Costs of the purchasing function, Purchasing function integrity, Quality, Continuous learning of purchasing staff, Contract management, Maturity of supplier management system, Supplier performance evaluation, Training, Amount of products purchased through e-catalogue, Supplier satisfaction, Forecast commitment
(Kumar et al. 2005)	Effectiveness of processing time, effectiveness of ordering time, Supplier delivery reliability, supplier evaluation, Quality of purchased materials, purchasing costs/prices of materials, supply chain, per order by customer, cost per order to suppliers, Effectiveness of department, Effectiveness of policies/procedures, Efficiency of policies/procedures, Training utilisation rate
(Rendon 2008)	Source selection, Contract closeout, Procurement planning, Solicitation planning

According to this table, we benchmark the most commonly used KPIs in the literature as our final variables to consider in the SD model. These KPIs are as follows: Cycle, Supplier performance, Agile, Quality, Supplier selection, Sustainability and Training. To build the SD model, the causal relationships between the KPIs were identified by domain experts. Experts were asked to provide their opinion regarding the casual relationships between the KPIs. Based on their opinions, a pool of suggested relationships was created and the relationships which were suggested by more than half of the experts were considered in the model. Based on that, the SD model was constructed as Figure 2.

A company's procurement performance is determined by its own internal KPIs. However, this performance is also affected by external factors which are out of the control of the company. For example, a better performance from a competitor will downgrade the performance of the company. Therefore, when considering the KPIs, we will also consider an external factor which might decrease the company's procurement performance. Regarding the company's internal KPIs which increase the

procurement performance, we will break down procurement performance into two factors; namely effectiveness and efficacy.

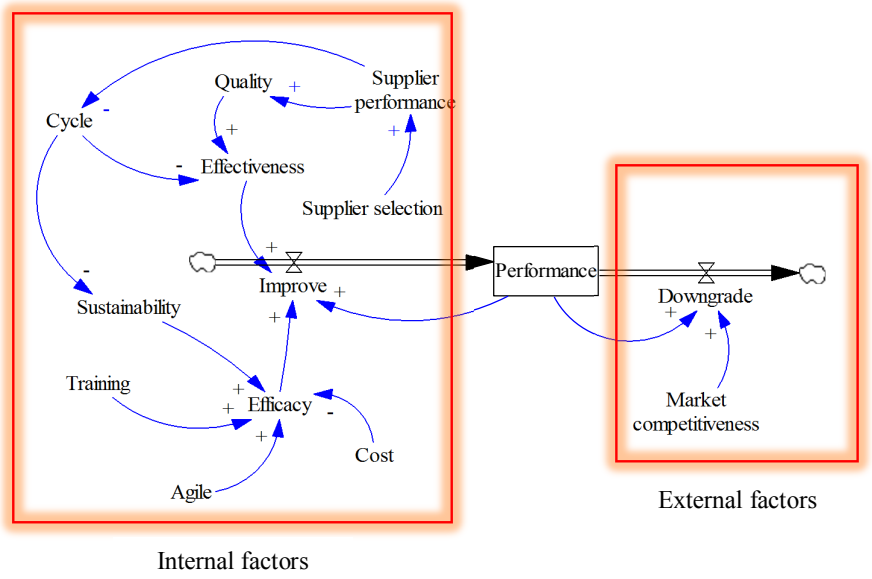

Fig. 1. A System Dynamics model for procurement performance prediction

According to the definition in the literature, effectiveness implies doing the right things. In terms of procurement, effectiveness can be defined as procuring the right thing, at the right time, and for the right price. On the other hand, efficacy implies performing the tasks in the best way. A main drawback of the literature regarding procurement performance measurement is that individual KPIs are not aggregated and utilized in a single model. The proposed model in this paper demonstrates a novel application of key performance indicators and shows how they can be combined as a system. The benefit of such aggregation is that the casual relationships between the KPIs are also considered, resulting into a measurement system with a more coherent output. In Figure 2, two rates control the accumulated level of performance. The improve rate increases the level of performance while the downgrade rate decreases the level of performance. We have also linked the accumulated level of performance to both of the improve rate and the downgrade rate. In reality, if a company's performance level is higher, it will have more resources to focus on R&D and improving the KPIs, which results into increasing the improve rate. Also, if a company's performance is higher, then it will be safer against the threats of competitors. Meaning that the enforced performance of the competitors will have less negative impact on the company's level of performance.

3 Model validation

3.1 Variable selection

One aspect in system dynamics modelling validation is that to make sure that the important variables have been considered in the model. To consider only top level variables or to break down the variables into many layers and increase the number of variables is subjective and depends on the application of the model. For instance, in our own model, we have decided to have only one variable for Cost as a representative of the total cost of the procurement process. One may decide to break down the costs associated with the procurement process into ordering cost, planning cost, cost of supplier selection, and so on. While this may increase the accuracy of the model, it will increase the complexity of the model as well. In our model, the KPIs for procurement have been selected based on a thorough review of the literature. Therefore, the most appropriate and significant KPIs have been considered in the model. Moreover, domain experts have confirmed the selection of the KPIs. In fact, the KPIs we have considered are the most common KPIs in the literature which are used to quantify the procurement process.

3.2 Consistency of dimensions

Another aspect for validation is to make sure the dimensions of the variables are consistent and compatible with each other. Consistency of dimensions has been checked and validated by using Vensim software.

3.3 Model behaviour in extreme conditions

Once the SD model is completed, it should be tested against extreme conditions. The models output and behaviour should match what could possibly happen in reality and be able to explained. This test is performed by setting those variables which have a constant value to their extreme possible values. The variables with a constant value are varied one at time and the models robustness against the extreme value for each variable is noted and explained. In our model, some of the variables are parent variables which themselves do not depend on any other variable(s). These variables were set to extreme conditions by Vensim software (one each time) and the output for our level variable (performance) was validated.

4 Conclusion

In this paper, a System Dynamics modelling approach was introduced for measuring, managing and predicting performance of the procurement process. Based on an in-depth review of the literature, the most common procurement KPIs were selected and considered in the model. The SD model proposed in this paper can be used for procurement performance measurement, procurement performance management or managing the procurement process, and finally procurement performance prediction.

By rewinding the initial time to a time in the past and setting the final time to a time close to the present, we can have an estimate of the procurement performance for the current time. By performing sensitivity analysis on the KPIs, the decision maker will have insights about how each KPI is affecting the overall performance level. Such information can be used for making decisions towards managing the procurement process. And finally, the most common use of SD modelling is to foresee the system's behaviour for a specific time in the future. This feature will allow us to predict the procurement performance. Performance prediction is strategically significant, as it allows decision makers to predict prospective possible poor performance and perform corrective actions/decisions before it becomes too late and the company is driven out the market by competitors.

5 References

1. Abdollahi, M., Arvan, M. & Razmi, J., 2015. An integrated approach for supplier portfolio selection: Lean or agile? *Expert Systems with Applications*, 42(1), pp.679–690.
2. Abolbashari, M.H. et al., 2018. Smart Buyer: A Bayesian Network modelling approach for measuring and improving procurement performance in organisations. *Knowledge-Based Systems*, 142, pp.127–148. Available at: https://www.sciencedirect.com/science/article/pii/S0950705117305622.
3. Balter, B.J.., 2011. Toward a more agile government: The case for rebooting federal IT procurement. *Public Contract Law Journal*, 41(1), pp.149–171.
4. Billow, H., 2014. Procurement performance and operational efficiency in telecommunication industry in Kenya. , (November).
5. Hovius, I.C., 2016. Improving purchasing performance of the UMCG Improving purchasing performance of the UMCG. , (March).
6. Kumar, A., Ozdamar, L. & Ng, C.P., 2005. Procurement performance measurement system in the health care industry. *International Journal of Health Care Quality Assurance*, 18(2), pp.152–166.
7. Luzzini, D. & Ronchi, S., 2016. Cinderella purchasing transformation : linking purchasing status to purchasing practices and business performance. , 7287(July).
8. Nair, A., Jayaram, J. & Das, A., 2015. Strategic purchasing participation, supplier selection, supplier evaluation and purchasing performance. *International Journal of Production Research*, 53(20), pp.6263–6278.
9. Patrucco, A.S., Luzzini, D. & Ronchi, S., 2016. Evaluating the Effectiveness of Public Procurement Performance Management Systems in Local Governments. *Local Government Studies*, 3930(July), pp.1–23.
10. Pohl, M. & Forstl, K., 2011. Achieving purchasing competence through purchasing performance measurement system design-A multiple-case study analysis. *Journal of Purchasing and Supply Management*, 17(4), pp.231–245.
11. Rendon, R.G., 2008. Procurement Process Maturity: Key to Performance Measurement. *Journal of Public Procurement*, 8(2).
12. Saad, S.M., Kunhu, N. & Mohamed, A.M., 2016. A fuzzy-AHP multi-criteria decision-making model for procurement process. *Int. J. Logistics Systems and Management*, 23(1), pp.1–24.
13. Waldron, B.D., 2008. Scope for improvement: A survey of pressure points in Australian construction and infrastructure projects.