Journal of Systems Thinking in Practice
JSTINP, *QUARTERLY*
Homepage: jstinp.um.ac.ir
Online ISSN: 2821-1669
Research Article
DOI: 10.22067/JSTINP.2022.78761.1023
JSTINP 2022; Vol. 1, No. 3

An Analysis of Influential Factors on Procurement Cycle Time Using a System Dynamics Approach

Mohammad Asghari[a*], Fatemeh Rostambeygi[b], Seyed Hossein Hosseini[c], Mohammad Motamedi[b]

[a] *Department of Logistics and Supply Chain, Faculty of Industrial Engineering, Iran University of Science and Technology, Tehran, Iran.*
[b] *Department of Industrial Engineering, Faculty of Engineering, University of Tehran, Tehran, Iran.*
[c] *Model-based Management Systems Institute (SAMAM), Tehran, Iran.*

How to cite this article

Asghari, M., Rostambeygi, F., Hosseini, S.H., and Motamedi, M., 2022. An Analysis of Influential Factors on Procurement Cycle Time Using a System Dynamics Approach. *Journal of Systems Thinking in Practice*, *1*(3), pp.75-91. doi: 10.22067/jstinp.2022.78761.1023.
URL: https://jstinp.um.ac.ir/article_43181.html.

ABSTRACT

Organizational agility is one approach that allows organizations to rapidly adapt to these conditions, which can be extended to the agility of individual business processes within the organization. Procurement cycle time is one of the most critical performance indicators that measure procurement process agility. This study will study the factors impacting procurement cycle time using a system dynamics modelling approach. To achieve this, the subsystems are defined and modelled, including internal subsystems like production and sales processes and external ones like market and suppliers. Next, the interactions of these subsystems are analysed, and the casual loops and stock-flow model of the problem are analysed and developed. The model has been implemented and validated in a production organization under the seasonal demand factor. Finally, three policies were proposed to reduce the procurement cycle time, and the simulation results of the policies were analysed numerically. According to the obtained results, combining the presented policies will lead to a 22% reduction in the procurement cycle time.

Keywords

Business process management, Supply chain management, System dynamics, Procurement cycle Time, Organizational agility.

Article history

Received: 2022-09-28
Accepted: 2022-12-05
Published (Online): 2022-12-05

Number of Figures: 12 **Number of Tables: 1** **Number of Pages: 17** **Number of References: 23**

**Corresponding author*
Email: mo_asghari@alumni.iust.ac.ir

[c] *SeyedHossein Hosseini is now a research fellow at the Brain and Mind Centre (BMC), The University of Sydney, Sydney, Australia. This research was conducted before he joined BMC.*

1. Introduction

New technological developments, shortening of product life cycles, diverse customer needs and increasing demand for a variety of products in the current global markets have greatly reduced the predictability of the market and exacerbated the uncertainty. According to these conditions, firms should have the necessary flexibility and agility to adapt to the socio-economic changes of the market so that they can maintain their competitive advantage (Almahamid, et al., 2010). Different definitions of organizational agility have been presented in the literature. These definitions include "the ability of a system to quickly respond to changes while maintaining the initial stability of the system" (Leybourn, 2013), "the ability to face unexpected challenges, deal with the risks of the business environment and use Changes as an opportunity" (Zhang and Sharifi, 2000) or "responding to customers and managing market changes" (Van Hoek, et al., 2001).

In addition, the increasing growth of firms and becoming more specialized has increased their need for goods and services outside the firm. In this regard, the procurement unit in every firm is responsible for meeting these needs from external sources; As a result, the increase in the firm's profit margin is dependent on the performance of the procurement unit through the rise in the ratio of the value to the price of the supplied goods and services (Pereira et al., 2014). An agile firm also needs an agile procurement process; Because this process has the task of supporting all the firm's operations. The procurement process helps the firm's agility by providing goods and services based on customer demand, quickly adapting to business environment changes, and using new solutions and resources (Nicoletti, 2018).

The main goal of agile procurement is to design and use a process that can plan capacity and coordinate the implementation of the procurement process. Riley and Brooks (2012) state the necessary factors for the agility of the procurement process as follows:

(1) Transparency of the whole process and having information about customers, suppliers and orders
(2) Increasing interaction between procurement and other departments, including customers and suppliers
(3) Control levers include hard levers, such as the use of organizational power (management pressure) and soft levers, such as organizational culture and training

Moreover, Chiang et al. (2012) listed the factors affecting the agility of the procurement process: 1- the level of response to requests (procurement cycle time) and 2- the degree of flexibility of the procurement process against the market changes).

Since the procurement cycle time is easier to quantify, it was chosen to investigate the agility factor of procurement. If the procurement cycle time increases, the number of production stoppages due to the lack of required materials and services increases. As a result, the firm is unable to fulfil its agreements with its customers, leading to the loss of credibility of the firm and its customers. This study will examine and predict the firm's agility using systems dynamics methodology. In order to increase agility, certain policies are designed and tested upon the discovered model.

In order to quantitatively investigate the problem, the data of a stationery production firm has been studied. The graph of the changes in the procurement cycle time in this firm in the investigated period is shown in Figure 1. As can be seen in this graph, the procurement cycle time has experienced almost 100% growth compared to the initial periods. Considering that the seasonal demand factor increases in periods 4 to 8 in the investigated problem, this issue increases the procurement cycle time in two ways. First, with the increase in demand for the firm's products, the number of goods requested for purchase has increased, leading to an increase in the procurement cycle time. Second, since this factor increases the supplier's demand, and on the other hand, each supplier has a limited capacity to prepare orders, therefore, with the increase in the requested goods, the procurement cycle time also increases.

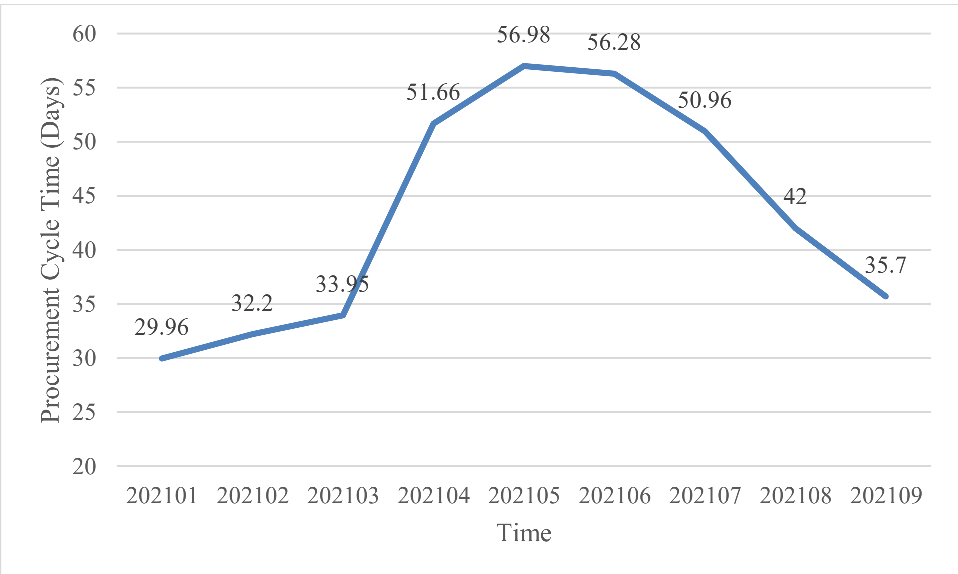

Figure 1. Diagram of changes in the procurement cycle time in the last 9 months of 2019

This paper is organized as follows. Section 2 reviews the related studies that have been carried out, section 3 presents the research methodology, in section 4 the problem would be modelled and validated based on case study historical data and also the model behaviour, and section 5 discuss and analyse the test results of designed policies and section 6 concludes on the presented model and obtained results.

2. Literature review

Ng et al. have identified three influencing factors on procurement cycle time. The first factor is the evaluation of suppliers. It means choosing a supplier who will send the ordered product quickly (Ng, et al., 1997). The next factor is the time of the procurement process itself within the firm. That is when a purchase requisition leads to a purchase order. The third factor is the firm-supplier relationship. This is because through the contract with the supplier, inspections can be done at the customer's site, and the inspection time can be reduced. In addition, inventory information can be shared so that when the order point is reached, the supplier can send the orders without going through the procurement process. Swafford et al. (2006) define the flexibility of the procurement process as the availability of different options when purchasing and the ability of the procurement process to change the selected options when needed. The meaning of these options is the ability to influence the procurement time and the supplier's capacity assigned to the firm. Firms with more suppliers have more options and a stronger bargaining position.

Abolbashari et al. (2018) have presented a dynamic model for measuring, managing and predicting procurement performance. They have considered influencing factors inside and outside the firm as subsystems of the problem. Besides, they used a concept called the “smart buyer”, which can measure purchase performance, manage purchase performance, and predict purchase performance. To study the performance of the procurement process, they used key performance indicators based on experts' opinions in the field as variables of the model and finally validated the model. Sawan et al. (2018) have developed a dynamic model to understand the factors influencing the cost of quality in the procurement of building materials using the traditional method of prevention/evaluation/failure. This model aims to identify opportunities to reduce quality costs without lowering quality. They have considered three subsystems of prevention costs, evaluation costs and failure costs in their model. Using the data of an operational project, the authors have simulated the model and analysed its results to evaluate different quality assurance policies. Barrad et al. (2018) have proposed a dynamic model to save costs through sustainable measures in the procurement process. They have investigated the impact of procurement manpower and their training on the number of strategic and sustainable contracts with suppliers and the performance of the procurement unit.

Cedillo-Campos and Sánchez-Ramírez (2013) have proposed a model to investigate supply chain logistics performance in an emerging competitive market by considering key performance indicators as dynamic variables. This article investigates three subsystems of procurement, distribution and production, and the presented model is implemented in an example in the automotive industry. Finally, they have validated their model through the method of design of experiments (DOE) and using the data of their case study. Chen and Tan (2020) have presented a model for the procurement process in the construction industry. In this model, three subsystems of material inventory, cost and project schedule have been examined. Finally, they simulated the presented model. According to the observed problems and the two variables of the average inventory turnover and time required for purchasing materials in advance, three strategies have been considered to solve these problems.

According to the literature above, system dynamics approaches have not been used enough to model the factors affecting procurement cycle times. As a result, this study attempts to simulate the procurement cycle time by examining the influential factors and quantitatively analysing the simulation model.

3. Methodology

Different methodologies have been introduced to qualitative model factors using system dynamics. Luna-Reyes and Andersen (2003) conducted a systematic literature review on these methodologies. There could be different stages of modelling a problem using a system dynamic approach, e.g., Sterman (2002) viewed the modelling steps as problem definition, dynamic hypothesis, formulation, testing, policy information and evaluation. This research has implemented the last methodology. To be more precise, in this research, first, the problem is described, and the variables affecting procurement cycle time are identified. Second, the influence of chosen variables on each other is analyzed and modeled using causal loop diagrams (CLD). Using The concept of CLD can help to better analyze and understand the problem, e.g., one can refer to (Kiani *et al.*, 2009; Hosseini and Hosseini, 2022). Third, the extracted simulation model is tested upon a real data set obtained from the case study. Fourth, three improvement policies are designed, and the procurement cycle time behavior is probed under these policies.

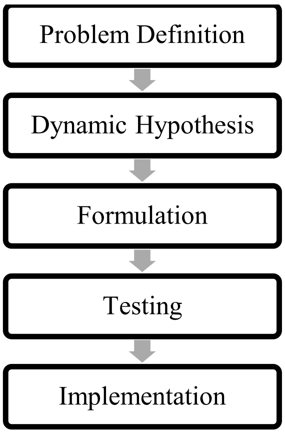

Figure 2. Research steps (Sterman,2002)

Figure 2 depicts the steps of described research methodology. It is to be mentioned that the case study data belongs to a stationery manufacturing company which is highly affected by seasonal demand, e.g., when the schools reopen in autumn, the demand for this product would boost significantly. It is to be noted that the dynamic assumptions of this research are developed based on current literature and also surveying the subject matter experts.

4. Problem definition

Here, we define our problem in a production firm. A manufacturing company's main value is created by selling manufactured goods (Terjesen et al., 2011). To that end, we have surveyed experts of the case study organization to obtain the current system status. In this case study, the sales department estimates the market demand through communication with customers and market studies or by receiving customer orders and preparing the sales plan. This plan is communicated to the planning department, and production commences on the production plan. On the other hand, the planning department registers the purchase requisition according to the inventory of raw materials and the production schedule. After reviewing the purchase requests, the procurement unit selects the appropriate supplier and registers the purchase order. After that, the supplier supplies ordered goods based on the internal capacity and the order of other customers and supplied goods are added to the inventory.

As seen in Figure 3, the procurement cycle time includes two parts: the time of converting a purchase request to a purchase order (the time of the internal procurement process) and the time of sending the goods by the supplier. The factor that affects the time of the internal procurement process is the type of transactions based on the transaction regulations. The classification that can be done in this case is the division of transactions into minor transactions and major transactions.

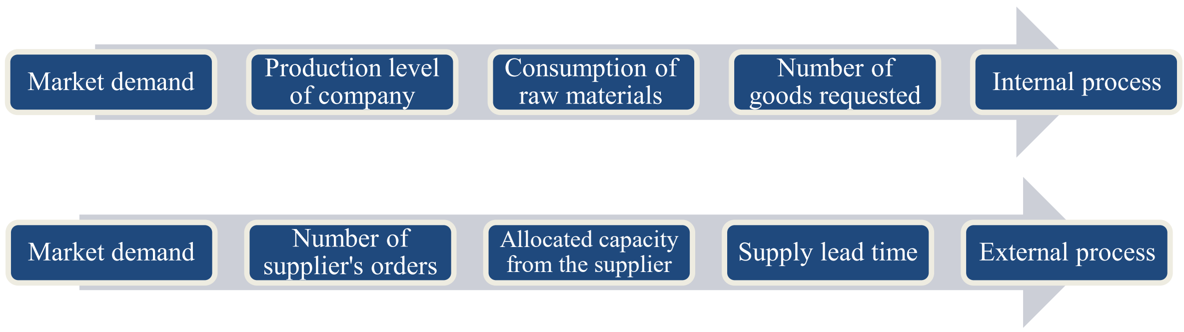

Figure 3. Overview of the problem

According to the procedure that must be done in order to carry out major transactions, the time of these transactions is longer than minor transactions. As the number of requested goods increases, the value of transactions increases and the possibility of being included in major transactions increases, and as a result, the time of the internal procurement process increases. On the other hand, with the increase in material consumption, the number of requested goods increases. With the increase in demand, the volume of production and operations of the firm will increase, which will cause an increase in the amount of material consumption. Another factor that affects the delivery time of the order from the supplier is the capacity allocated to supply the order. If the orders of other customers of the supplier increase, the supplier will allocate less capacity to the firm's order. As the market demand for the supplier's products increases, the orders of other customers also increase. Figure 4 shows the subsystems of the problem.

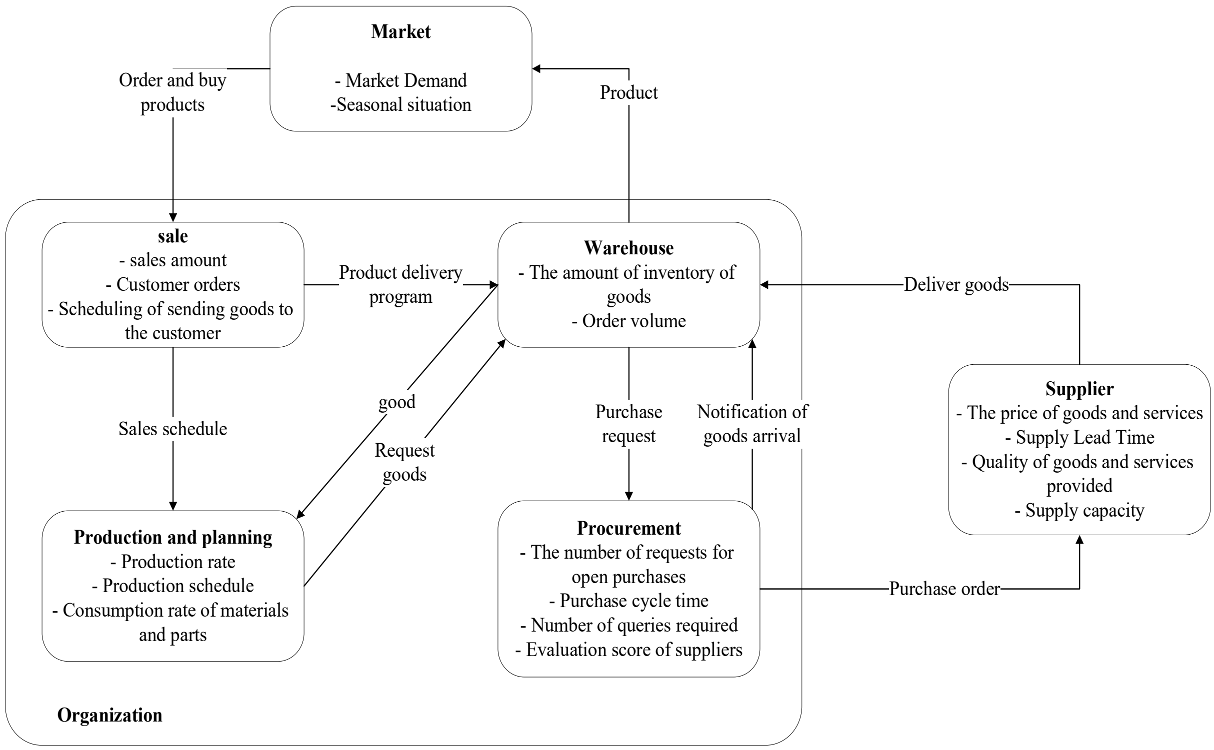

Figure 4. Subsystems of the case study

5. Modelling, review and analysis of data

5.1. Casual loops

The following are the causal loops of product inventory, procurement and supplier. As mentioned in section 4, the sales department estimates the market demand through communication with customers and market studies or formulates a sales schedule by receiving customer orders. As a result, with the increase in market demand, the firm's number of sales (planned and unplanned sales) also increases. The production schedule is a function of the firm's product inventory and the number of sales. As the production plan increases, the volume of production and operations of the firm increases, and as a result, the inventory of the firm's products also increases. On the other hand, with the increase in production, the consumption rate of raw materials for product production increases. As a result, the inventory level of raw materials decreases. With the decrease in raw material inventory level, the amount of product production also decreases. (Poles, 2013) presented a dynamic model of product inventory, which Figure 5 is an adaptation of this model.

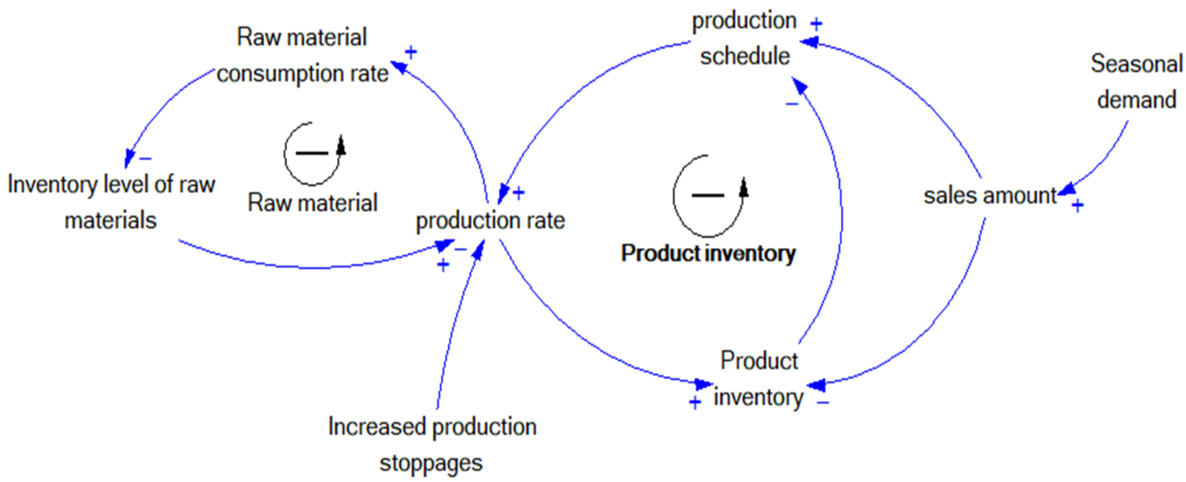

Figure 5. Structure of product and raw material inventory loop

With the increase in the number of items requested, the number of items in the order queue to be checked by the procurement expert increases and as a result, due to the price of raw materials, the time of the internal procurement process also increases. Also, as the time of the internal procurement process increases, the number of goods in the order queue is ordered with a greater delay. These ordered goods are added to the goods in the supplier's processing queue. As a result, due to the capacity of the supplier, it increases the time of supplying the order from the supplier. The longer the order supply time is, the more the number of products in the supplier's processing queue will be supplied with a greater delay. The supplied goods are added to the inventory of raw materials, which decreases and increases the requested goods.

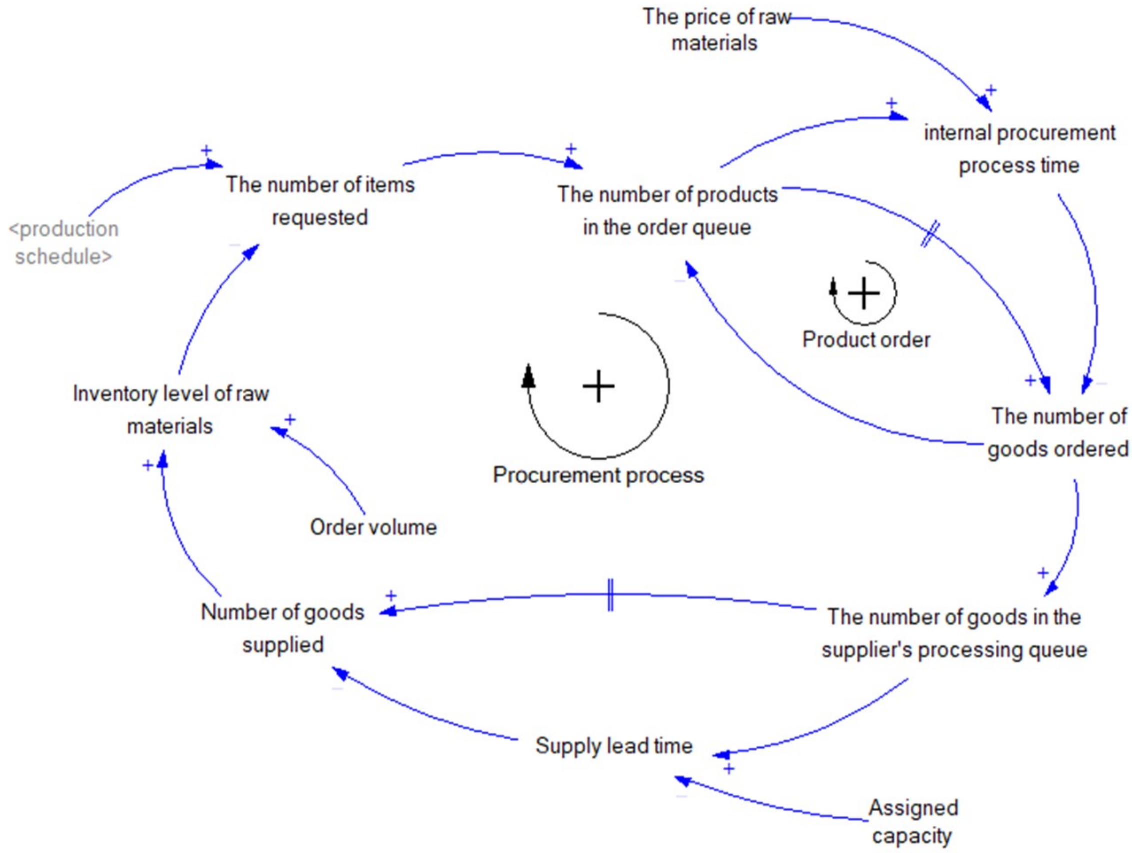

Figure 6. Structure of procurement process loop

As has been mentioned, one factor that affects the order supply time is the capacity that the supplier has allocated to our firm, which is affected by the supplier's total capacity and the orders of other customers. On the other hand, seasonal demand is a factor that affects the demand of other customers as well (Rafiei, et al., 2014). With the increase in the order supply time and the time of the internal procurement process, the procurement cycle time increases, which will lead to irreparable stops (Figure 7). As a result, the amount of production will decrease as depicted in Figure 6. Figures 5 and 6 were inspired by (Abolbashari, et al., 2018) and modified according to the conditions of the case study.

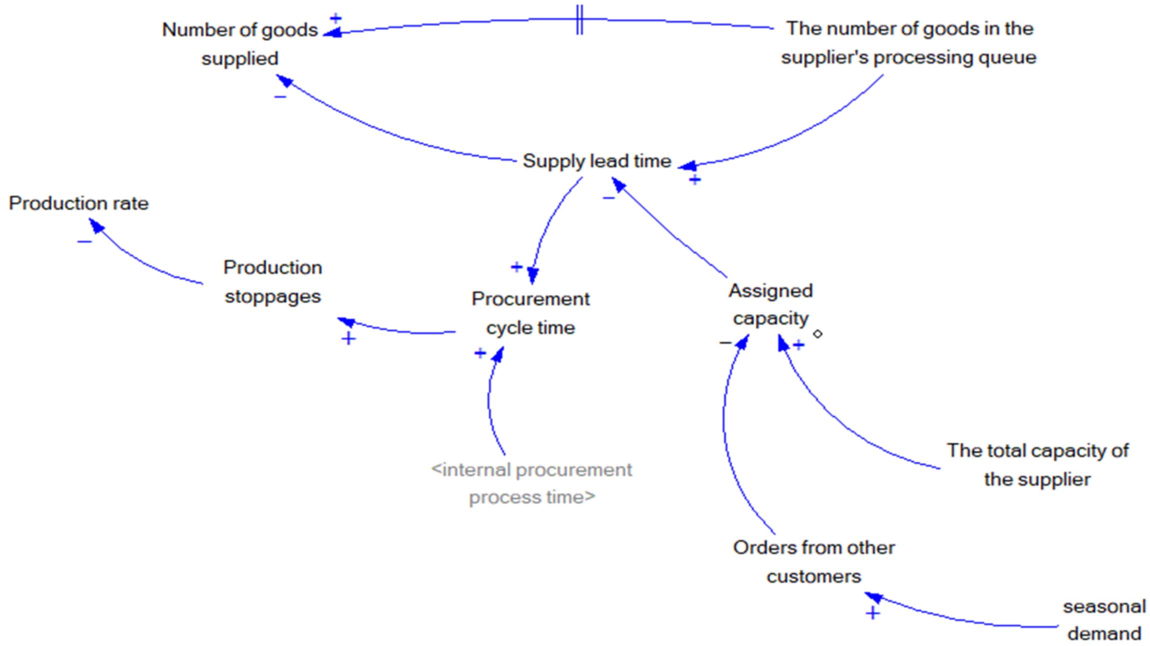

Figure 7. Factors affecting the procurement cycle time

5.2. Stock-flow diagram

The Stock -flow diagram of the problem is described in Figure 8. In this model, we have assumed that the desired product is produced from two raw materials with a constant consumption factor. Four types of stock variables are considered in equations 1-6:

(1) The number of goods in the order queue from raw material i ($NGOQ_i$)

(2) The number of goods in the supplier's processing queue from raw material i ($NGPQ_i$)

(3) Inventory of raw material i (RI_i)

(4) Product inventory produced by the firm (PI)

$$NGOQ_i = \begin{cases} NGR_i - NGO_i & if\ NGR_i \geq NGO_i \\ 0 & else \end{cases} \quad (1)$$

$$NGPQ_i = \begin{cases} NGO_i - NGS_i & if\ NGS_i \leq NGO_i \\ 0 & else \end{cases} \quad (2)$$

$$RI_i = \begin{cases} NGS_i - CC^{1}_i * P^{2} & if\ CC_i * P \leq NGS_i \\ 0 & else \end{cases} \quad (3)$$

$$PI = P - S^{3} \quad (4)$$

$$NGO_i = DELAYFIXED(NGOQ_i, IPCT^{4}, 0) \quad (5)$$

$$PCT^{5} = IPCT + SLT^{6} \quad (6)$$

---

[1] Consumption Coefficient of raw material i used in final product
[2] Production
[3] Sales
[4] Internal Procurement Cycle Time
[5] Procurement Cycle Time
[6] Supplier Lead Time

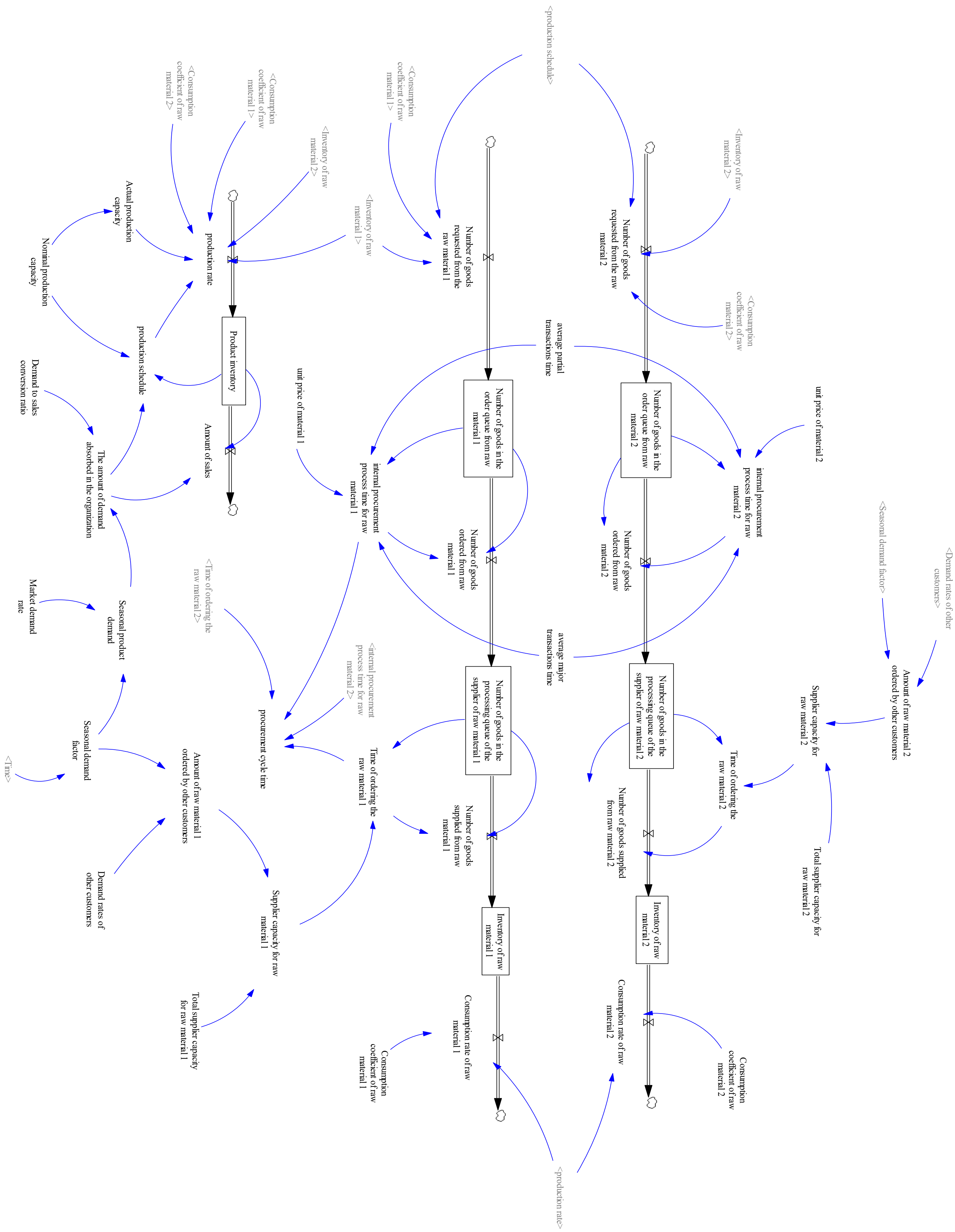

Figure 8. Stock-flow diagram of the procurement cycle time

5.3. Validation

System dynamics models are always built with a specific goal in mind. Therefore, it is not possible to say that the model is correct or incorrect, but its validity can be examined continuously.

5.3.1. Behavior reproduction test

The effects of formulas and equations are compared to the real system for this test. The graphs obtained from the model made by Vensim are compared with the graphs obtained from historical data. Next, the diagram related to this test for the procurement cycle time is given in Figure 9.

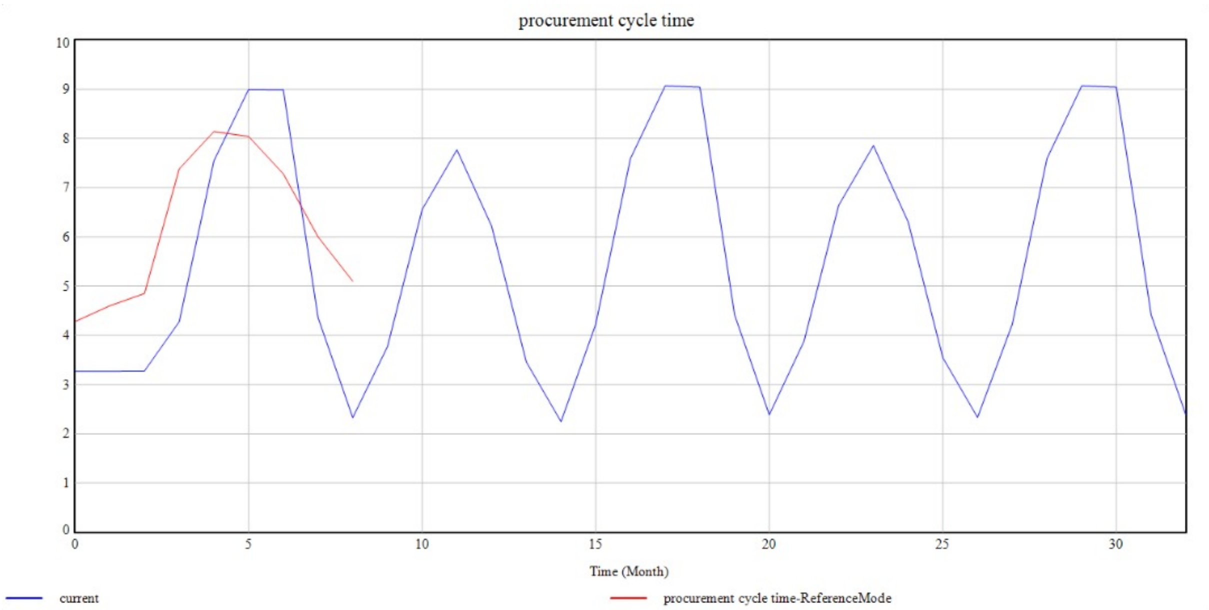

Figure 9. The first validation test (procurement cycle time)

As shown in Figure 9, the model's behaviour in the first 6 months of the simulation time is the same as the behaviour of the reference diagram. In this way, in the last quarter of the year, considering that the seasonal demand increases, the amount of production increases, and as a result, the purchase cycle also increases at that time. In the first quarter of the year, because the seasonal demand is less, the time of the purchase cycle is also downward, and this behaviour can also be seen in the graph.

5.3.2. Extreme condition test

In this test, to check whether the dynamics of the model work in different situations, the conditions and formulas of a number of variables are changed, and the results are examined.

According to Figure 10, the procurement cycle time behaviour will be affected if the nominal production capacity increases or decreases.

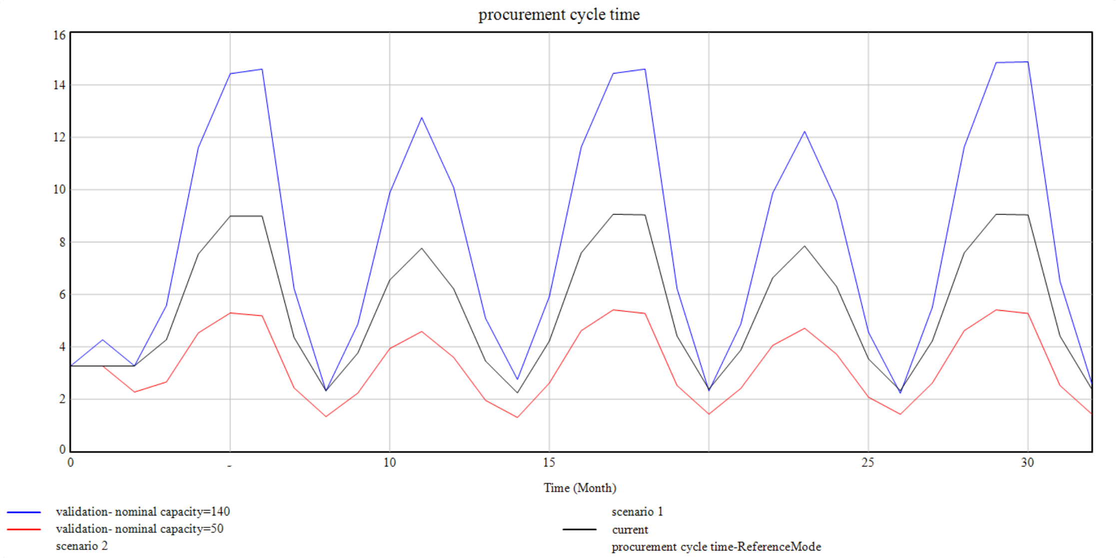

Figure 10. The second validation test (procurement cycle time with nominal capacity 20 and 140)

If the total capacity of the supplier is reduced, the amount of capacity allocated to the firm will be reduced, so the order supply time will also increase. As a result, the procurement cycle time also increases. This behaviour can also be seen in Figure 11.

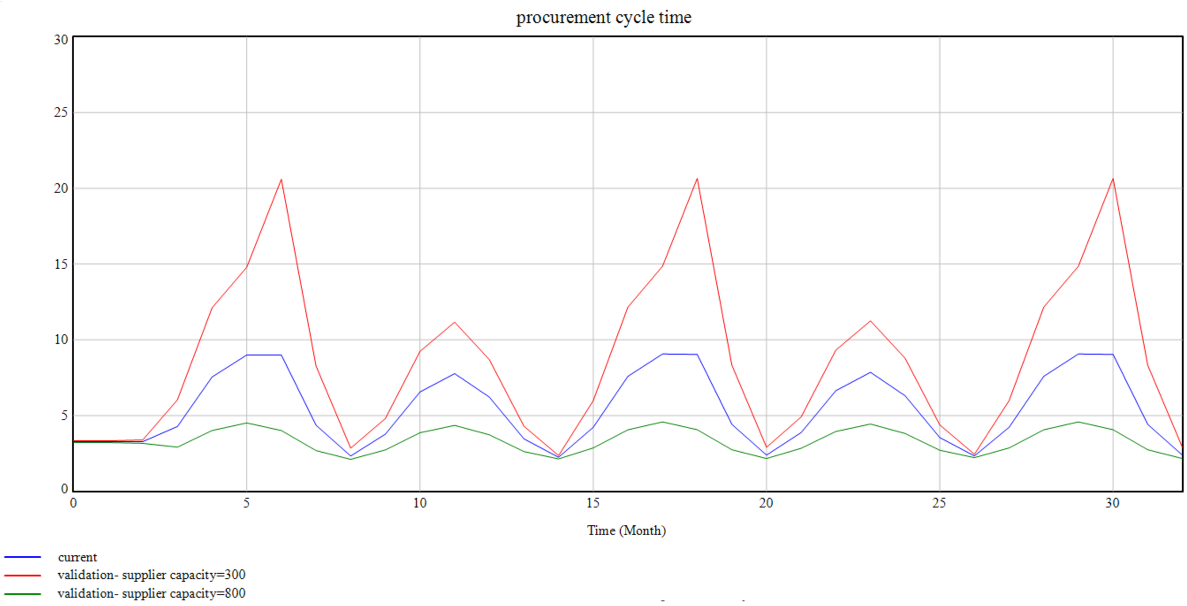

Figure 11. The third validation test (procurement cycle time with supplier capacity of 300 and 800)

As can be seen from Figures 10 and 11, either the nominal production capacity and the supplier's capacity change, the procurement cycle time will be affected so that by increasing the supplier's capacity and decreasing the nominal production capacity, the procurement cycle time can be reduced.

6. Discussion

As far as we know, there are not many papers addressing the procurement cycle time reduction issue. Laradi et al. developed a simulation model to measure the procurement cycle time under outsourcing and insourcing policy (Laradi, et al., 2015). They considered the effect of technical expertise and project financing as two major factors. Nicoletti studied the procurement process performance under the lean thinking methodology (Nicoletti, 2018). He showed applying this approach could result in the reduction of waste in procurement and also a decrease in overall procurement cycle time. In this research, an attempt has been made to investigate the effect of various factors on the increase in procurement cycle time using a model and to reduce this time as much as possible by applying policies.

For this purpose, one of the policies that can be considered is renting the supplier's capacity by the firm. The seasonal demand affects the supplier's capacity to meet the firm's demand, causing fluctuations in the procurement lead time. Renting a certain percentage of the supplier's capacity can reduce these fluctuations, reducing the procurement cycle time. Another way that can be considered to reduce the procurement cycle time is to reduce the time of the internal procurement process. Since the major part of the internal procurement process is the time of major transactions, the firm can reduce this time by adopting processes such as process automation. Since both these policies are costly for the firm, it is worth studying the effects; therefore, one can cost-benefit and prioritize these initiatives. As shown in Figure 12, applying this policy reduces the procurement cycle time by 16% on average in different periods. This ultimately leads to a 5% reduction in the average procurement cycle time in different intervals. In addition, another solution that can be presented is the combination of the two policies. In this sense, if the firm has enough budget and time to implement both policies, it can combine the two policies, which ultimately reduces the procurement cycle time by 22% on average. Table 1 shows a summary of the impact of these policies.

Table 1. The impact of policies

Row	Policy	Impact
1	Renting Supplier production capacity	16% reduction in procurement cycle time
2	Reducing the average time of major transactions	5% reduction in procurement cycle time
3	Combining the above two policies	22% reduction in procurement cycle time

As seen in Figure 12, if it is possible to apply both policies in combination, the greatest improvement is achieved. Otherwise, according to Figure 11 and simulation results, it is better to apply the first policy first.

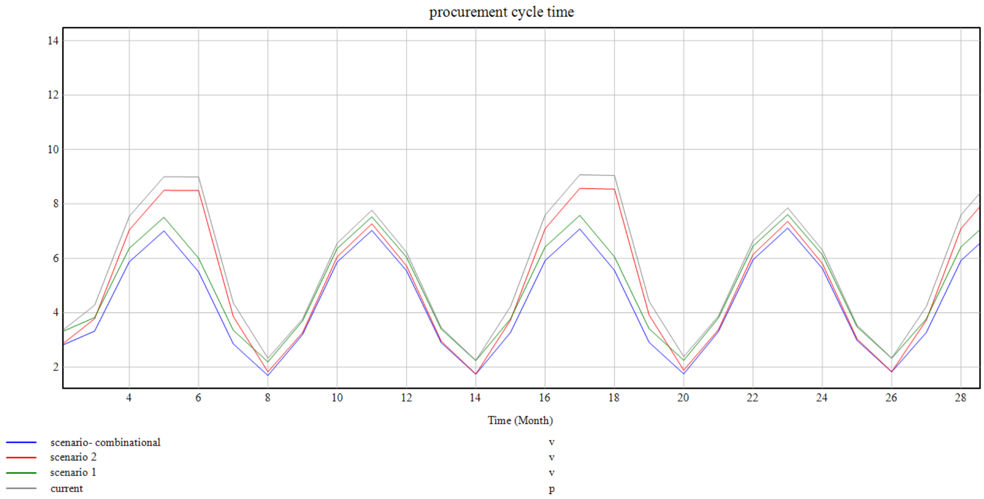

Figure 12. Comparison of procurement cycle time in different policies

7. Conclusion

This research attempted to examine one of the most important criteria of procurement process agility, i.e., procurement cycle time with a systems approach. Based on a case study, a system dynamics model describing affecting factors on procurement cycle time was presented and validated according to the available data from the process. Then several policies were proposed to improve this agility index. Finally, the presented policies were analysed numerically, and according to the results of this research, the effect of reducing the order supply time on the procurement cycle time is greater than reducing the time of the internal procurement process; This issue can help firms as a management tip. According to the results obtained from the simulation of the presented model, the combination of the presented policies leads to a 22% reduction in the average procurement cycle time. For future research, in addition to the procurement cycle time, other topics affecting the agility of the procurement process, such as flexibility, can also be considered. It is also possible to examine other market dynamics that affect the demand factor, such as global disruptions in the supply chain, political and social conditions, the spread of infectious diseases such as Corona, and other such factors.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Abolbashari, M.H., Zakeri, A. and Chang, E. 2018. Using system dynamics for predicting an organization's procurement performance, in *IFIP, Advances in Information and Communication Technology*. Springer New York LLC,*538*, pp.294–299. https://doi.org/10.1007/978-3-030-00828-4_29.

Almahamid, S., Awwad, A. and McAdams, A.C. 2010. Effects of organizational agility and knowledge sharing on competitive advantage: an empirical study in Jordan, *International Journal of Management*, *27*(3).

Barrad, S., Valverde, R. and Gagnon, S. 2018. The application of system dynamics for a sustainable procurement operation, in *Innovative Solutions for Sustainable Supply Chains*. Springer Verlag, pp.179–196. https://doi.org/10.1007/978-3-319-94322-0_7.

Cedillo-Campos, M. and Sánchez-Ramírez, C. 2013. Dynamic self-assessment of supply chains performance: An emerging market approach, *Journal of Applied Research and Technology*, *11*(3), pp.338–347.

Chen, T. and Tan, B. 2020. Research on Project Resource Allocation and Lean Procurement Strategy Based on System Dynamics', *Academic Journal of Business & Management*, *2*(5), pp.25–36. https://dx.doi.org/10.25236/AJBM.2020.020504.

Chiang, C.Y., Kocabasoglu-Hillmer, C. and Suresh, N. 2012. An empirical investigation of the impact of strategic sourcing and flexibility on firm's supply chain agility, *International Journal of Operations and Production Management*, *32*(1), pp.49–78. https://doi.org/10.1108/01443571211195736.

Van Hoek, R.I., Harrison, A. and Christopher, M. 2001. Measuring agile capabilities in the supply chain', *International Journal of Operations and Production Management*, *21*(1–2), pp.126–147. https://doi.org/10.1108/01443570110358495.

Hosseini, A. and Hosseini, S.H.. 2022. A System Dynamics Approach to Sustainable Business Model Transformation: A Manufacturing Case, *Journal of Systems Thinking in Practice*, *1*(1), pp.24–48 https://doi.org/10.22067/jstinp.2022.76303.1010.

Kiani, B. *et al.,* 2009. Using Causal Loop Diagram to Achieve a Better Understanding of e-Business Models.', *International Journal of Electronic Business Management*, *7*(3), pp.159–167.

Laradi, M., Olomolaiye, A. and Douraid, A. 2015. Modeling trading & procurement cycle based on insourcing and outsourcing strategy, in *Proceedings of the 2015 International Conference on Operations Excellence and Service Engineering, Orlando: USA*.

Leybourn, E., 2013. *Directing The Agile Organisation: A lean approach to business management*. IT Governance Ltd. Available at: https://www.jstor.org/stable/j.ctt5hh6fh.

Luna-Reyes, L.F. and Andersen, D.L. 2003. Collecting and analyzing qualitative data for system dynamics: methods and models, *System Dynamics Review: The Journal of the System Dynamics Society*, *19*(4), pp.271–296. https://doi.org/10.1002/sdr.280.

Ng, B., Ferrin, B.G. and Pearson, J.N. 1997. The role of purchasing/transportation in cycle time reduction', *International Journal of Operations and Production Management*, *17*(6), pp.574–591. https://doi.org/10.1108/01443579710167267.

Nicoletti, B. 2018. Agile Procurement, in *Agile Procurement*. Palgrave Macmillan, Cham.

https://doi.org/10.1007/978-3-319-61082-5_3.

Pereira, C.R., Christopher, M. and Lago Da Silva, A. 2014. Achieving supply chain resilience: the role of procurement, *Supply Chain Management: An International Journal*, *19*(5/6) pp.626–642. https://doi.org/10.1108/SCM-09-2013-0346.

Poles, R. 2013. System Dynamics modelling of a production and inventory system for remanufacturing to evaluate system improvement strategies', *International Journal of Production Economics*, *144*(1), pp.189–199. https://doi.org/10.1016/j.ijpe.2013.02.003.

Rafiei, H., Rabbani, M. and Hosseini, S.H. 2014. Capacity Coordination under Demand Uncertainty in a Hybrid Make- To-Stock/Make-To-Order Environment: A System Dynamics Approach', *Scientia Iranica*, *21*(6), pp.2315–2325.

Riley, S. and Brooks, D. 2012. Follow the Path to Agility*, Supply and Demand Chain Executive*. Available at: https://www.sdcexec.com/sourcing-procurement/article/10784962/follow-the-path-to-agility.

Sawan, R., Low, J.F. and Schiffauerova, A. 2018. Quality cost of material procurement in construction projects', *Engineering, Construction and Architectural Management*, *25*(8), pp.974–988. https://doi.org/10.1108/ECAM-04-2017-0068.

Sterman, J. 2002. System Dynamics: systems thinking and modeling for a complex world. Available at: http://hdl.handle.net/1721.1/102741.

Swafford, P.M., Ghosh, S. and Murthy, N. (2006) 'The antecedents of supply chain agility of a firm: Scale development and model testing', *Journal of Operations Management*, *24*(2), pp.170–188. https://doi.org/10.1016/j.jom.2005.05.002.

Terjesen, S., Patel, P.C. and Covin, J.G. 2011. Alliance diversity, environmental context and the value of manufacturing capabilities among new high technology ventures, *Journal of Operations Management*, *29*(1–2), pp.105–115. https://doi.org/10.1016/j.jom.2010.07.004.

Zhang, Z. and Sharifi, H. 2000. A methodology for achieving agility in manufacturing organisations, *International Journal of Operations and Production Management*, *20*(4), pp.496–513. https://doi.org/10.1108/01443570010314818.