Advanced Logistic Systems – Theory and Practice, Vol. 18, No. 1 (2024), pp. 99-106.
https://doi.org/10.32971/als.2024.010

IMPLEMENTATION OF MODELLING SHIP-TO-SEQUENCE SUPPLY STRATEGIES

JÁNOS JUHÁSZ[1] – TAMÁS BÁNYAI[2]

Abstract: *The supply chain processes are key to improving the cost efficiency and sustainability of manufacturing and service companies. One of the most innovative strategies of just-in-sequence supply is the ship-to-sequence, which offers improvement possibilities over traditional just-in-time approaches. This paper focuses on the implementation of modelling ship-to-ship supply, especially the basic mathematical modelling in these strategies.*
It not only evaluates the entire supply process, but it enables a thorough examination of a comprehensive analysis of the financial impact of ship-to-ship supply for both suppliers and end-users. It goes beyond the analysis of the entire supply process; it allows an examination of selected processes at deeper levels and evaluates the impact of different factors on financial indicators.

Keywords: *supply chain, logistics, JIS*

1. INTRODUCTION

The development of just-in-sequence (JIS) supply chain design methods is a priority research area in the manufacturing and service industry environment, especially in the efficient and cost-effective business management of traditional and complex processes. In manufacturing, efficient and effective processes are important for producing raw materials into finished products. This includes all manufacturing and service activities from assembly line operations to quality control measures, inventory management, and logistics coordination. Streamlining these processes not only improves productivity but also reduces costs and enhances overall competitiveness [1].

The long-term operation of these company operations is crucial because manufacturing processes are supported by the logistics activities which are the basis of the service systems. The companies consider it as a priority research area to efficiently perform traditional and complex logistics functions [2]. This highlights the critical importance of streamlining processes, optimizing resource allocation, and enhancing overall operational effectiveness to remain competitive in today's dynamic business landscape.

Our research addresses the implementation of ship-to-sequence supply strategies' general mathematical modelling to describe and evaluate some typical system variations in the planning, design, and sustainable development of internal and external corporate logistics processes.

2. LITERATURE REVIEW

Based on the international literature, the just-in-sequence (JIS) supply is considered a renewal of Just-in-Time (JIT) principles, because it enables the benefits of standard supplier processes and standard certifications [3]. The JIS supplier philosophy is no other than a central element of lean thinking [4]. These methodologies offer a systematic approach to

[1] senior lecturer, Ph.D., University of Miskolc, Institute of Logistics, Miskolc, Hungary
janos.juhasz1@uni-miskolc.hu
[2] full professor, Ph.D., University of Miskolc, Institute of Logistics, Hungary
tamas.banyai@uni-miskolc.hu

inventory management, production scheduling, and logistics coordination, allowing organizations to optimize their operations and focus on their core business objectives.

The traditional JIT and JIS solutions support the supply chain processes of the company. It focuses on the supply chain processes that enable companies to shift their manufacturing operations to a more efficient JIS-based supply chain:

- the efficient and cost-effective operation of traditional and complex business processes,
- is crucial to serve the multimodal logistics activities and
- to handle logistics tasks.

The development of manufacturing and service processes embraces the entire supply chain because it eliminates uncertainties and unnecessary activities [5]. The application of different methods, using different algorithms, can reduce the risks involved in the production process, which ensures the evaluation of the decision principles [6].

These concepts help to innovate supply chain-based manufacturing processes and to control the fulfilment of related services:

- improving the traditional supply chain [7],
- adapting modern and innovative methods in manufacturing and supply processes, and
- the provision of intermediate goods [8],
- to achieve higher quality of services,
- to reduce the environmental impact,
- reducing harmful emissions,
- scheduling and delivery of desired products to serve customers at the lowest cost throughout the supply chain [9],
- highlights the main network characteristics of each production system by planning [10] and scheduling [11] resources for logistics activities.

Thus, there is an important role for the allocation and scheduling of resources related to the smooth servicing of supply chain processes [12].

3. DESCRIPTION OF THE JUST-IN-SEQUENCE STRATEGIES

In this section, the objectives are to review the three basic just-in-sequence strategies, the literature suggests three main types of just-in-sequence care strategies:

- ship-to-sequence,
- pick-to-sequence, and
- build-to-sequence strategies.

These three basic Just-in-Sequence (JIS) strategies are fundamental approaches used in supply chain management to ensure that components and materials are delivered to the production line in the correct sequence required for assembly.

Just-in-sequence (JIS) strategies hold high importance in modern supply chain management due to their ability to enhance efficiency, minimize waste, and improve overall operational performance.

These just-in-sequence strategies enable companies to respond quickly to changes in customer demand or production requirements.

Implementing just-in-sequence strategies requires close collaboration of each tier between suppliers, manufacturers, and logistics providers. This collaboration fosters transparency, communication, and efficiency throughout the supply chain, leading to smoother operations and improved customer satisfaction.

The difference between the three just-in-sequence delivery strategies is as follows:

- ship to sequence: the requested products are delivered to the user in the requested sequence, even directly to the assembly line.
- pick to sequence: the products are not delivered to the user in the required sequence, but the user builds the sequences himself from the available stock.
- build to sequence: the user manufactures the required products in order of the sequence, the supplier is responsible for delivering the necessary parts for the manufacture of the products, this can be taken into consideration depending on the complexity of the mathematical model.

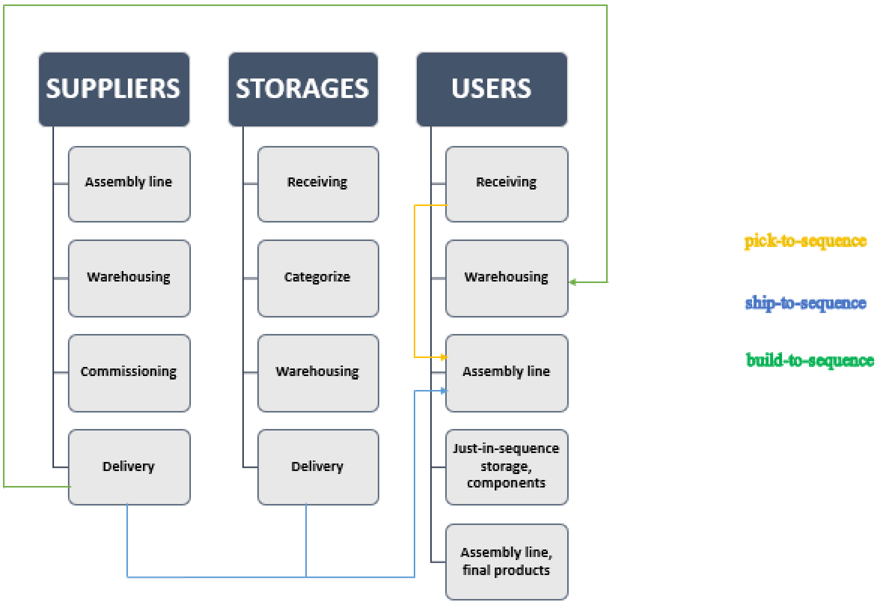

Figure 1. Just-in-sequence delivery models [Own edit]

Fig. 1 summarizes the differences between each just-in-sequence strategy: The ship-to-sequence delivery model that manufacturing of assembly line products takes place at an earlier point in the supply chain. The required parts are assembled according to the right sequence of the just-in-sequence supply and processed to the users' assembly lines by the suppliers. The pick-to-sequence delivery model is that the assembly line components are handled by the users and delivered to the assembly lines according to the JIS. The difference in the pick-to-sequence strategy is that the products are not delivered to the user in sequence, the user builds the sequences from the available stock. The build-to-sequence delivery model demonstrates that assembly line production is now only carried out at an earlier point in the supply chain if own production cannot be solved. Normally, the required sequence of components is handled and delivered to the users' assembly lines by the manufacturer. Thus, the user manufactures the required products itself according to the sequence in the build-to-sequence supply, which can be defined as a function of the complexity of the model.

Based on the above reasons, the research aims to focus on the field of material flow modelling, which helps to plan and design logistics processes in companies.

4. IMPLEMENTATION OF GENERAL MODELLING SHIP-TO-SEQUENCE SUPPLY STRATEGIES

Based on the above ideas, the present study is limited to the scope of traditional, just-in-time, and just-in-sequence deliveries.

While there exist numerous other strategies and methodologies in the broader field of logistics and supply chain optimization, focusing on these three fundamental approaches allows for more in-depth analysis and comparison of their respective impacts, advantages, and limitations.

Supply chain servicing is defined by the following cost components:

- natural costs,
- the supply costs.

The natural costs of using natural resources:

$$C^{NAT} = C^G + C^E + C^U, \tag{1}$$

where:

- C^G is the specific cost of greenhouse emissions,
- C^E is the electricity cost of suppliers,
- C^U is the specific cost of unexpected natural resources for suppliers.

The costs of logistics activities and other services in the ship-to-sequence supply chain:

$$C^{SC} = C^S + C^W + C^D + C^M, \tag{2}$$

where:

- C^S is the operating cost of suppliers,
- C^W is operating cost of warehouses,
- C^D is the operating cost of delivery carriers,
- C^M is the operating cost of manufacturer, assembly lines.

The problem's objective function describes the minimization of supply chain operational costs:

$$C = \sum_{i=1}^{m} \sum_{j=1}^{n} C^{NAT}.x_{ij} + \sum_{i=1}^{m} \sum_{j=1}^{n} C^{SC}.x_{ij} \rightarrow min, \tag{3}$$

where:

- x_{ij} is an assignment matrix of users, suppliers, and associated sequences, where i=1...m and j=1...n, there is a direct connection between them,
- these focus on the supply chain processes which enable companies to improve their business operations towards more modern and competitive just-in-sequence supply.

5. RESULTS

In this chapter, we examine the ship-to-sequence model in supply chain processes. This model has objective function components which guarantee and support the required sequences in manufacturing processes.

Based on the information provided, the value of supply chain operational costs for suppliers (i), users (j), products (k), and sequence (t) are determined using random functions within Excel.

A large number of parameters will not be presented, only summarized in the detail of the sum of sequence values.

Table I shows the costs of ijk t sequences that can be measured and calculated in the supplier-user relation. Thus, it can be exactly determined the supply and natural costs of required sequences.

Table I.

Detail of sum of sequence values [Own edit]

$SZUM$ t	C_S [t€]	C_W [t€]	C_D [t€]	C_M [t€]	C_{NAT} [t€]	B_{SHIP} [t€]
1 1 1	0.05	0.54	0.02	0.01	0.07	0.54
1 1 2	0.05	0.74	0.02	0.02	0.06	0.74
1 1 3	0.04	0.31	0.02	0.01	0.07	0.31
1 1 4	0.00	0.95	0.02	0.02	0.09	0.95
1 1 5	0.06	0.51	0.02	0,.02	0.09	0.51
1 1 6	0.05	0.26	0.02	0.03	0.06	0.26
1 1 7	0.03	0.36	0.01	0.02	0.04	0.36
…	…	…	…	…	…	…
3 3 6	0.02	0.95	0.01	0.01	0.09	0.95
3 3 7	0.04	0.26	0.02	0.02	0.06	0.26
3 3 8	0.02	0.57	0.01	0.01	0.06	0.57
3 3 9	0.02	0.28	0.02	0.01	0.07	0.28
3 3 10	0.06	0.27	0.01	0.01	0.07	0.27

Fig. 2 represents the partial costs of each sequence, which cost on average 0.58 eEUR. From this, the cheapest cost 0.15 eEUR and the most expensive cost 1.53 eEUR.

The numerical analysis, which is essentially a virtual case study based on the proposed models, demonstrates the applicability and understandability of the model.

Fig. 3 shows the breakdown and the percentage of these cost components, where the sequence values were calculated to determine the whole operational cost of the system.

The above calculations can be used to determine and evaluate the costs of ship-to-sequence supply. Thus, the total cost of the ship-to-sequence supply system is 51.30 eEUR and the revenue from its activities is 51.97 eEUR.

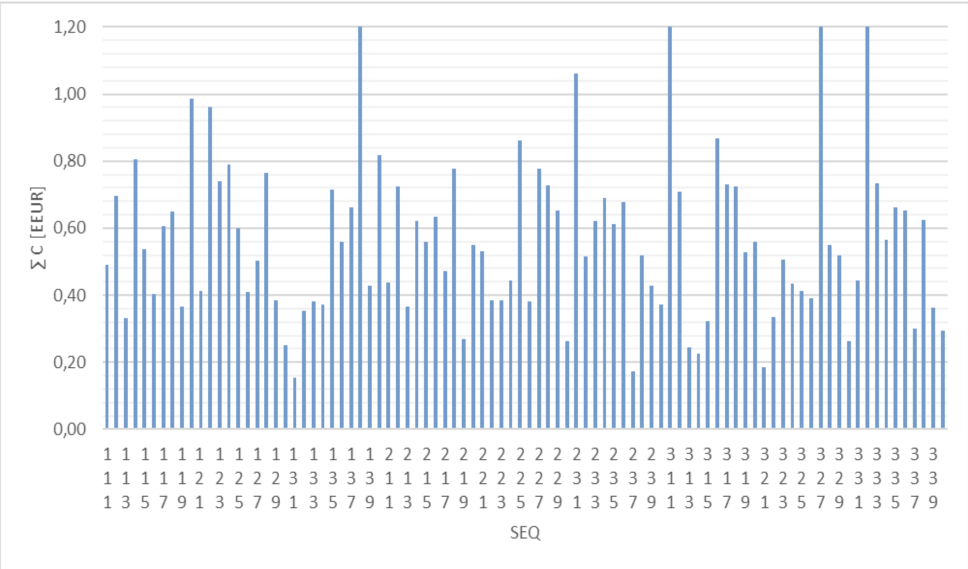

Figure 2. Breakdown of each just-in-sequence delivery costs [Own edit]

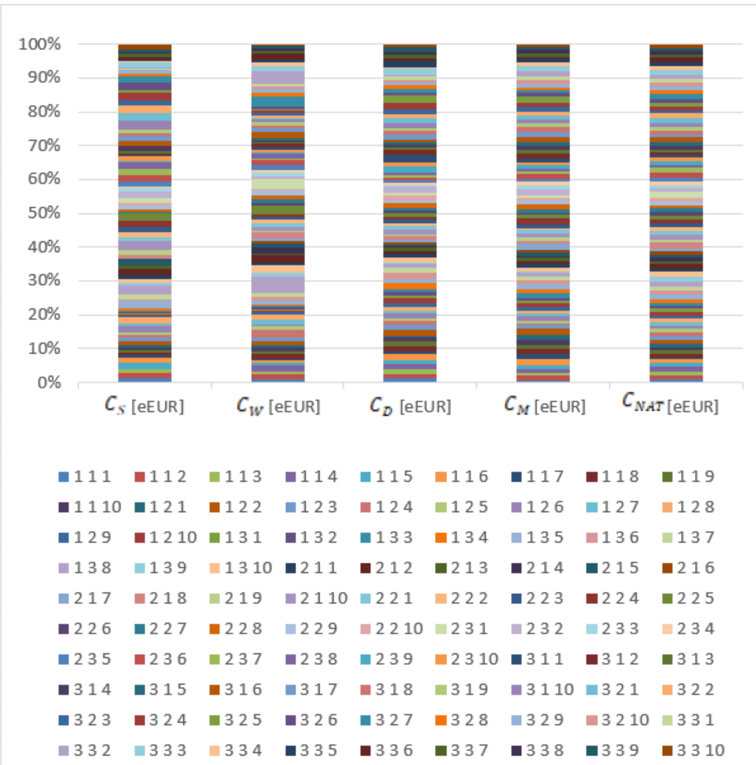

Figure 3. Results of ship-to-sequence just-in-sequence costs calculations [Own edit]

6. Summary

The initial mathematical modeling of ship-to-sequence supply strategies supports the design of optimal system parameters for basic strategies. The supply strategies can be tested using mathematical models. These methods can effectively synchronize production with demand, particularly in the context of managing both traditional and intricate processes.

In essence, the importance of JIS strategies lies in their ability to transform supply chain operations, driving efficiency, cost-effectiveness, and competitiveness in today's dynamic business environment. As companies strive to meet evolving customer expectations and navigate complex supply chain challenges, JIS strategies play a crucial role in achieving success and sustainable growth.

The three just-in-sequence supply strategies can be also used to evaluate and compare the consistency of companies' just-in-sequence supply chain processes, especially in terms of the cost of operating the company. It can be used to find the optimal just-in-sequence strategy, to select the more advantageous model. This requires the complex modeling of mathematical models and hybrid just-in-sequence model interpretation, where the basic models are combined.

References

[1] Boysen, N., Fliedner, M. & Scholl, A. (2009). Level Scheduling for batched JIT supply. *Flexible Services and Manufacturing Journal* **21**(1-2), 31-50, http://www.doi.org/10.1007/s10696-009-9058-z

[2] Bányai, T. & Bányai, A. (2017). Modelling of just-in-sequence supply of manufacturing processes. *MATEC Web of Conferences* **112**, 06025, https://doi.org/10.1051/matecconf/201711206025

[3] Wagner, S. M. & Silveira-Camargos, V. (2011). Decision model for the application of just-in-sequence. *International Journal of Production Research* **49**(19), 5713-5736, https://doi.org/10.1080/00207543.2010.505216

[4] Juhász, J. & Bányai, T. (2021). Understanding the purchasing portfolio model: A just-in-sequence approach increasing manufacturing efficiency. *Journal of Applied Engineering Science* **19**(4), 926-933, https://doi.org/10.5937/jaes0-30742

[5] Cedillo-Campos, M. G., Ruelas, D. M., Lizarraga-Lizarraga, G., Gonzalez-Feliu, J. & Garza-Reyes, J. A. (2017). Decision policy scenarios for just-in-sequence deliveries. *Journal of Industrial Engineering and Management* **10**(4), 581-603, https://doi.org/10.3926/jiem.2090

[6] Boysen, N. & Emde, S. (2014). Scheduling the part supply of mixed-model assembly lines in line-integrated supermarkets. *European Journal of Operational Research* **239**(3), 820-829, https://doi.org/10.1016/j.ejor.2014.05.029

[7] Bassil, S., Keller, R. K. & Kropf, P. (2004). A Workflow-Oriented System Architecture for the Management of Container Transportation. *Lecture Notes in Computer Science* (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) **3080**, 116-131, http://www.doi.org/10.1007/978-3-540-25970-1_8

[8] Srisuruk, W., Sudtachat, K. & Horkaew, P. (2021). Biobjective Scheduling for Joint Parallel Machines with Sequence-Dependent Setup by Taking Pareto-Based Approach. *Modelling and Simulation in Engineering*, 6663375, http://www.doi.org/10.1155/2021/6663375

[9] Thibbotuwawa, A., Bocewicz, G., Nielsen, P. & Zbigniew, B. (2019). Planning deliveries with UAV routing under weather forecast and energy consumption constraints. *IFAC-PapersOnLine* **52**(13), 820-825, http://www.doi.org/10.1016/j.ifacol.2019.11.231

[10] Herrmann, J. W. (2012). Finding optimally balanced words for production planning and maintenance scheduling. *IIE Transactions* **44**(3), 215-229, http://www.doi.org/10.1080/0740817X.2011.602660

[11] Akturk, M. S. & Erhun, F. (1999). An overview of design and operational issues of kanban systems. *International Journal of Production Research* **37**(17), 3859-3881, http://www.doi.org/10.1080/002075499189808

[12] Juhász, J. (2023). *Just-in-sequence ellátási láncok tervezési módszereinek fejlesztése*, Ph.D. dissertation, University of Miskolc, http://dx.doi.org/10.14750/ME.2023.034