Scientific Journal of Silesian University of Technology. Series Transport
Zeszyty Naukowe Politechniki Śląskiej. Seria Transport

Volume 93 **2016**

p-ISSN: 0209-3324

e-ISSN: 2450-1549

DOI: https://doi.org/10.20858/sjsutst.2016.93.10

Journal homepage: http://sjsutst.polsl.pl

Article citation information:
Mańka, I., Mańka, A. Cost analysis and optimization in the logistic supply chain using the SimProLOGIC program. *Scientific Journal of Silesian University of Technology. Series Transport*. 2016, **93**, 91-97. ISSN: 0209-3324.
DOI: https://doi.org/10.20858/sjsutst.2016.93.10.

Ilona MAŃKA[1], Adam MAŃKA[2]

COST ANALYSIS AND OPTIMIZATION IN THE LOGISTIC SUPPLY CHAIN USING THE SIMPROLOGIC PROGRAM

Summary. This article aims to characterize the authorial SimProLOGIC program, version 2.1, which enables one to conduct a cost analysis of individual links, as well as the entire logistic supply chain (LSC). This article also presents an example of the analysis of the parameters, which characterize the supplier of subsystems in the examined logistic chain, and the results of the initial optimization, which makes it possible to improve the economic balance, as well as the level of customer service for a sample test task.
Keywords: logistic chain of supplies; SimProLOGIC program; polioptimization; cost analysis in the logistics supply chain; storage cost

1. INTRODUCTION

The issues concerning the cost optimization in an LSC constitute the subject of topical research in many scientific centres [8, 10, 11, 12]. The holistic/complete cost analysis of a supply chain is referred to as supply chain costing in the specialist literature. In accordance with the latest trends in this discipline, many scientists are abandoning the approach, which

[1] Faculty of Transport, University of Dąbrowa Górnicza, Cieplaka 1C Street, 41-300 Dąbrowa Górnicza, Poland. Email: ilonam78@gmail.com.
[2] Faculty of Transport, Silesian University of Technology, Krasińskiego 8 Street, 40-019 Katowice, Poland. Email: adam.manka@polsl.pl.

promotes the competition between individual companies in favour of the competition between entire supply chains [12]. This approach will be effective only when it leads to the coordination of the entire chain, taking into consideration the amount of supplies, dates, costs and the effective flow of information.

2. TASKS PERFORMED IN THE SIMPROLOGIC PROGRAM

It is possible to designate the most beneficial conditions for the end customer, i.e., the lowest price, taking into account the assumed level of customer service [1], only by means of the polioptimization of the parameters of all elements of an LSC (the suppliers of subsystems, the producers of finished goods, retail stores), as well as taking into consideration transport, the choice of the means of transport, the consolidation of supplies and the management of warehouses. The authors of this article, based on the SimProLOGIC application, have concluded that the number of variables having an influence on the final result of LSC optimization, i.e., the retail price of goods, and the quality of provided services (the availability of the goods for the customer and the minimization of the stocks), i.e., market success or failure (not only one company, but the whole chain of supplies), reaches up to 114 variables, taking into consideration the minimum chain of supplies as shown in Figure 1. The aforementioned number of variables, which characterize the minimum LSC, include:

- the supplier of subsystems (in a simplified way, only one) = nine variables,
- transport, taking costs into account = 18 variables,
- the input warehouse of the producer of finished goods = 14 parameters,
- the production department (excluding technical and quality parameters of the goods) = 12 parameters,
- the output warehouse = 14 parameters,
- transport, taking costs into account = 18 variables,
- a retail store, taking into consideration the level of customer service = 17 variables,
- a simplified model of the customer (the model of market demands) = 12 variables.

For such a great number of variables, it is extremely difficult to find an optimal solution, taking into account an objective function, which takes into consideration the minimum final costs, i.e., the price of goods, while aiming to reach the required level of customer service. Taking into consideration the aforementioned number of 114 parameters, which influence the subtotals of the individual links of the supply chain, it has been stated that it is sensible to develop software, which would simulate LSC functioning and enable one to make a selection of the basic parameters using logistic tools such as:

- the permanent order quantity method,
- the permanent order period method,
- the consolidation of supplies,
- the choice of means of transport and order quantity,
- the selection of warehouse space and size.

The most important component of the LSC simulator under development, i.e., the SimProLOGIC program, is the possibility of conducting many analyses and observations of the quality of provided services, taking into account quality and quantity, for various input parameters. The visualization of results for individual chains of an LSC enables one to conduct quantity analyses. However, in the early stages of the exploitation, it is possible to illustrate the operation of individual subdivisions, including stoppages concerning the supplier of subsystems, the waiting period before shipment and the prolonged duration of transport (the likely change of the type of transport, the introduction of many vehicles, the consolidation of supplies, the quantity of order changes), the producer's productivity/performance, and the effectiveness of warehouse selection. It is also possible to make a qualitative and quantitative evaluation of the quality of customer service by implementing the following indicators:

- the annual (r index) and monthly (m index) availability indicators of the level of customer service (POKd),
- the annual and monthly reserve/resource indicators of the level of customer service (POKz),
- the annual indicator of the equity of sale in relation to warehouse dimensions (SM).

These indicators were discussed in detail in [1].

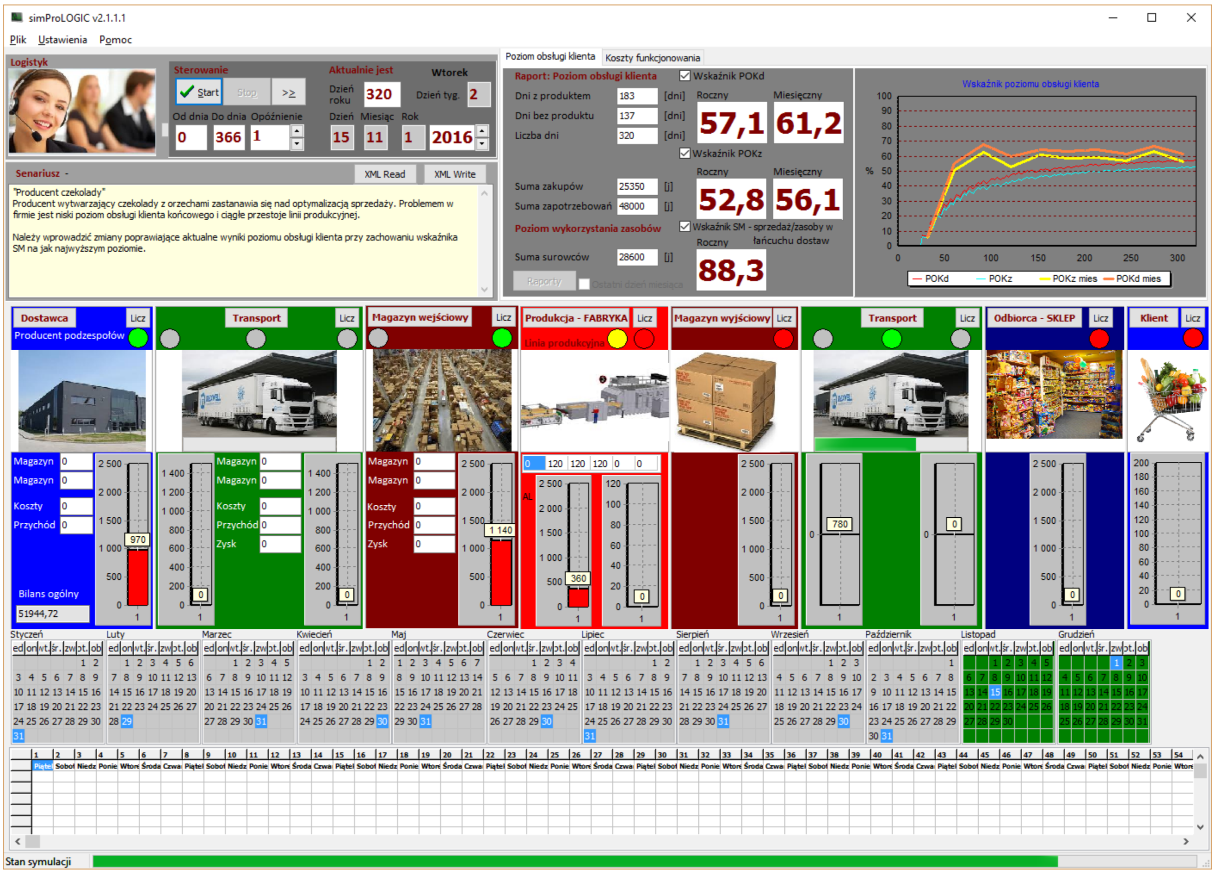

Fig. 1 The view of the main window of the SimProLOGIC program (version 2.1), which contains the models of basic components of the LSC

Apart from the analysis of the influence of individual parameters, which characterize the links of the LSC at the level of customer service, the analysis of costs was also introduced to the SimProLOGIC program, version 2.1. These costs result from the classical approach to economic analysis within the management of the chain of supplies. They take into consideration:

- the fixed costs of the company/entity,
- the fixed costs of warehousing (as a percentage of the value of goods annually),
- the variable costs dependent on the production volume,
- the variable costs associated with the loss of production capacity,
- the variable costs dependent on the quantity of stored resources,
- the costs of the product,
- the transport costs.

Apart from the costs, the income concerns the sales of goods, a subsystem or the income associated with the transport services and the profit margin of the shop.

The exemplary structure of costs is shown in Figure 2. The solution shown in this figure, which involves the selection of parameters associated with the supplier of a subsystem, was developed using an iterative method, while the objective function was to minimize the warehousing costs (1) and maximize the overall balance (2) in the minimum possible duration (3). Assuming that the fixed costs in the analysed task (4), warehousing costs (5) and product costs (6), as well as the price of sale of a subsystem (7), are unchangeable, the decisive factors are the working days (8), the size of the warehouse (9) and the daily production volume (10).

The presented example is based on the scenario, which concerns the production of the selected kind of chocolate (see Fig. 1). By introducing the corrections of baseline values of the size of the warehouse, i.e., 3,000 [j] (the unit of the quantity of goods; to be precise, multipacks containing 25 items), and the daily production from the value of 500 [j] to 1,600 [j] and 130 [j] respectively (Fig. 2), we have achieved a warehousing cost reduction from PLN21,686.86 to PLN5,515, while the income has increased from PLN23,013.14 to PLN51, 944.72. This means that, by reducing the daily production to 26% of the baseline value and decreasing the size of the warehouse assigned to this subsystem, one has gained more than a 200% increase in income. The chart also enables one to read the time after which one receives an overall positive balance of the supplier's operation, i.e., initially, it amounted to 296 days. However, following the correction of only two measurements, the recovery/refund period was reduced to 175 days. It is worth emphasizing that the selection of these parameters is facilitated due to the possibility of conducting the analysis of the whole process and the verification of the demand in the preceding and the following links, as well as ultimately in a retail store and in the model of a customer. The problems associated with the operation of an individual link are perfectly visible in this case, due to the opportunity to observe the indicator, which represents (using colours) the process of production (green) and the time during which there is no production process in a link because of the fact that the output warehouse is full, or because of deficiencies in the input warehouse or days off from work.

It is important that the presented result regarding the initial selection of parameters for the subsystem supplier improved the results for this link in the LSC. Nevertheless, there has been no significant improvement in the economic parameters and the level of customer service. The reason for this is the fact that the LSC should not be treated in terms of separate mechanisms, but as a single system of correlated modules. This is why, at further stages, one should adapt the values of further modules and subsequently return to the first module in order to introduce further corrections, which will be necessary because of the already modified demand and the frequency of supplies for the producer of finished goods and the changes introduced in further links. The current version of the SimProLOGIC program, i.e. 2.1., does not enable one to select and polioptimize the parameters of the whole LSC. The parameters should be selected in an iterative way using the simulation and observation of the behaviour of the analysed and neighbouring links. The efficient method of the optimization of the whole chain is its analysis, i.e., of the customer and the initial link, in both directions. It enables one to characterize the real needs of the customers and the initial evaluation of the flow of materials in the entire LSC. Another verified strategy of optimization is to increase the performance of production and the transport of all links, irrespective of costs, in order to acquire the maximum source stream for the customer. Only in the preceding link should one reduce the availability of resources in order to provide the minimum level of customer service, thereby gradually reducing the performance of further links in the direction towards the original link (here represented as a supplier of subsystems).

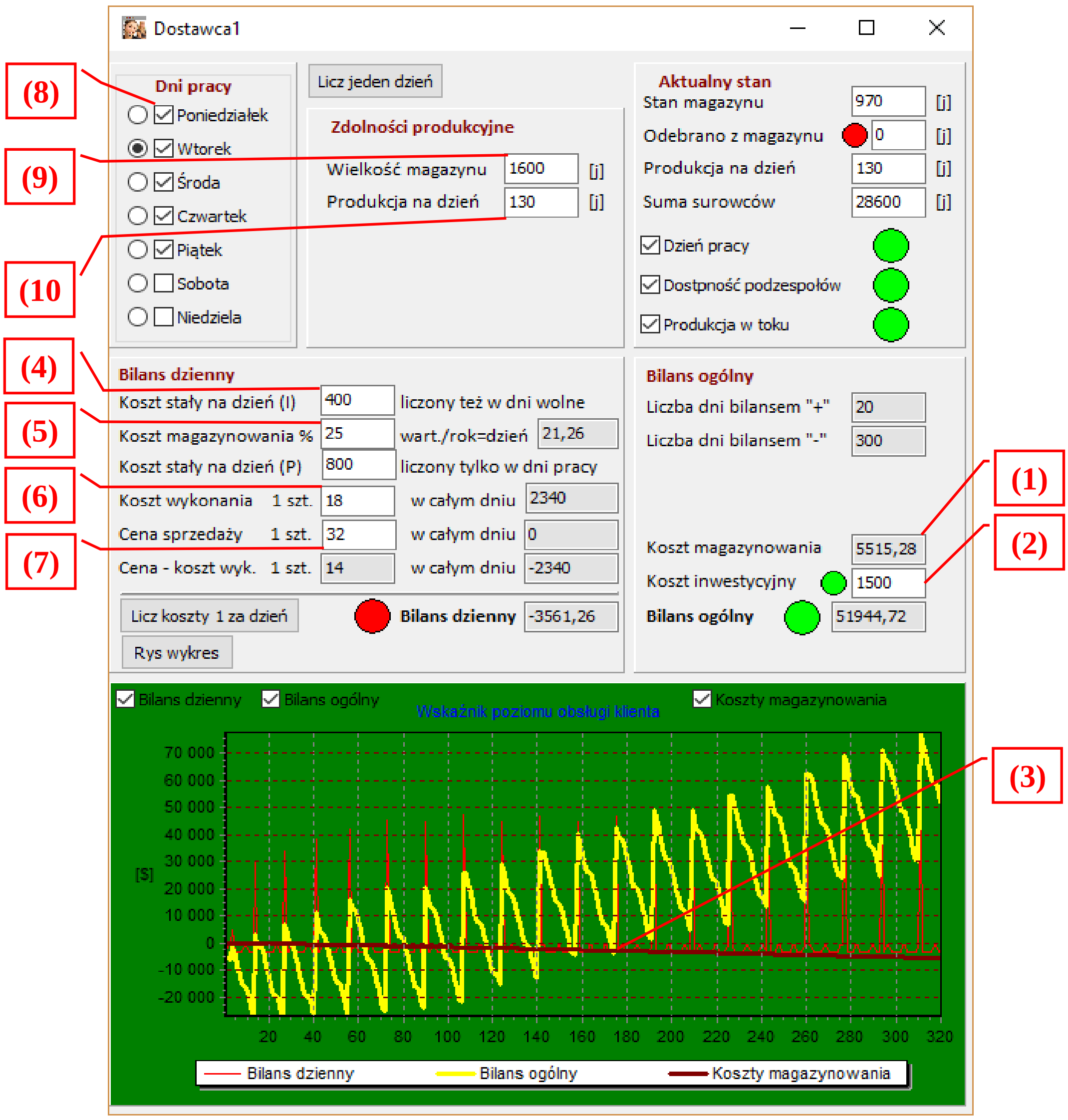

Fig. 2 The example of cost analysis for the supplier of subsystems in the SimProLOGIC program (please note: number formats are in Polish, e.g., 70 000 = 70,000)

Interesting results also concern the analysis of the decreased number of days (in a week) devoted to production in general or the production of subsystems for the analysed finished goods. It has been stated that the additional working day, namely, Saturday, reduces the profitability of the operations. Therefore, it is possible to conduct a comparative analysis, which enables one to receive an answer as to whether it is more beneficial to produce subsystems in smaller quantities, rather than in accordance with production capacity or production involving full capacity, but only from Monday to Thursday inclusive.

The presented example concerns the first element of the modelled LSC. However, these operations are realized in all links of the chain, thereby enabling one to gain the intended final result, i.e., an increase in effectiveness and cost reduction, while, at the same time, increasing income across the entire logistic chain. The assumed level of customer service is ensured simultaneously. In the given example, one can also see the didactic application of the aforementioned software, which enables one to acquire the skills and practical experience in the management of the supply chain in the chosen examples, which constitute the library of the exemplary scenarios. These scenarios require the student either to undertake action to reach the requested level of customer service, to minimize the total cost or to search for the bottleneck of the analysed LSC. It is also possible to present analyses, which require one to take into account the management of the size of the warehouse or to take decisions concerning the selection of the means of transport (the duration and cost of transport) or the supplied volumes.

3. CONCLUSION

This article has presented the subsequent version of the authorial SimProLOGIC program, supplemented by a cost analysis of the whole LSC. The presented results concerning the analysis and optimization of parameters, albeit only for an individual link (the supplier of subsystems), show the potential offered by the presented simulator in the field of the practical application of, and the didactic process associated with, logistics and management. The presented system encompasses several aforementioned methods of analysis used in the didactic process at universities, which are associated with solutions to logistic problems, thereby increasing its didactic value.

The course of further work and development is associated with the expansion of the system by a larger number of suppliers of subsystems and a larger number of retail outlets. It is also planned to expand the customer models in order to make it possible to take into account the variables of consumer behaviour and the factors associated with chance. It also seems to be worthwhile to improve the user’s interface to improve the clarity of the ongoing processes. Simultaneously, we have been searching for new methods for solving problems related to engineering tasks associated with logistics in order to enable one to implement them in software, especially the methods concerning automatic multi-criteria optimization (114 variables).

References

1. Mańka, I., Mańka, A. 2014. „Symulacja wpływu zmienności popytu i dostaw na poziom zapasów w przedsiębiorstwie". [In Polish: "Simulation of the variability of demand and supply on the level of stocks in the company"]. *Logistyka* 6: 14431-14439. ISSN 1231-5478.
2. Bendkowski Józef, Grażyna Radziejowska. 2011. *Logistyka Zaopatrzenia w Przedsiębiorstwie*. [In Polish: *Logistics Supply in a Company*]. Gliwice: Silesian University of Technology. ISBN 978-83-7335-875-1.
3. Coyle John, Edward Bardi, John Langley. 2010. *Zarządzanie Logistyczne*. [In Polish: *Logistics Management*]. Warsaw: Polish Economic Publishing House. ISBN 978-83-208-1864-2.
4. Krzyżaniak Stanisław, Piotr Cyplik. 2008. *Zapasy i Magazynowanie*. [In Polish: *Stocks and Storage*]. Poznan: Institute of Logistics and Warehousing. ISBN 978-83-87344-58-0.
5. Krzyżaniak Stanisław. 2002. *Podstawy Zarządzania Zapasami w Przykładach*. [In Polish: *Basics of Exemplary Stock Management*]. Poznan: Institute of Logistics and Warehousing. ISBN 978-83-87344-83-2.
6. Lysons Kenneth. 2004. *Zakupy Zaopatrzeniowe*. [In Polish: *Supplying Purchases*]. Warsaw: Polish Economic Publishing House. ISBN 83-208-1473-1.
7. Majewski Jerzy. 2007. *Informatyka w Magazynie*. [In Polish: *Informatics in the Warehouse*]. Poznan: Institute of Logistics and Warehousing. ISBN 978-83-873445-2-8.
8. Mindur Leszek. 2014. *Technologie Transportowe.* [In Polish: *Transport Technologies*]. Radom: Institute for Sustainable Technologies. ISBN 978-83-7789-244-2.
9. Sarjusz-Wolski Zdzisław. 2000. *Sterowanie Zapasami w Przedsiębiorstwie*. [In Polish: *Wresting Control from Enterprise*]. Warsaw: Polish Economic Publishing House. ISBN 83-208-1272-0.
10. LOG24. "Optymalizacja kosztów w logistyce". [In Polish: Cost optimization in logistics]. Available at: http://www.log24.pl/artykuly/optymalizacja-kosztow-w-logistyce,4957.
11. Tomasz Zieliński. 2007. „Koncepcje i narzędzia wspierające zarządzanie kosztami w łańcuchach dostaw". [In Polish: "The concepts and tools to support cost management in supply chains"]. Available at: http://www.logistyka.net.pl/bank-wiedzy/item/5390-koncepcje-i-narzedzia-wspierajace-zarzadzanie-kosztami-[]-w-lancuchach-dostaw.

Received 09.10.2016; accepted in revised form 25.10.2016