# TOWARDS MORE EFFICIENT LOGISTIC SOLUTIONS: SUPPLY CHAIN ANALYTICS

**Svetlana Nikoličić [a,*], Marinko Maslarić [a], Dejan Mirčetić [a], Alin Emanuel Artene [b]**

[a] University of Novi Sad, Faculty of Technical Sciences, Serbia

[b] Polytechnic University of Timisoara, Faculty of Management in Production and Transportation, Romania

---

***Abstract:*** *If something cannot be measured, it cannot be managed. This principle can be directly applied in the logistics and supply chains. Establishing and determining the logistical performance and supply chain performance represents the first step towards effective management of these systems. The second step is to use the set of contemporary analytical tools to enhance the effectiveness of logistics and supply chain processes. This is exactly the topic of this paper, since in the era of digitalization., due to the enormous amount of data generated on a daily basis, traditional knowledge and approaches cannot be used to manage logistics and supply chains. In response to technological changes and changes in business processes, the Big Data value is being increasingly studied along with the application of various analytical techniques to support the efficient flow of materials along the supply chain, that is, to effectively plan and manage the supply chain. The aim of this paper is to summarize and describe the existing knowledge about supply chain analytics and to explore how much this issue is being studied at faculties.*

***Keywords***: *logistics performances, big data, supply chain analytics.*

---

## 1. INTRODUCTION

The functioning of a logistic system results in the flow of materials and related information and is based on the application of various logistic strategies and the use of a wide range of resources and services within and outside individual companies. Logistics performance measures are used to determine logistic effects as well as to plan and manage logistics systems and processes. Considering that: Logistics management activities typically include inbound and outbound transport management, fleet management, warehousing, materials handling, order fulfillment, logistics network design, inventory management, supply/demand planning, and management of third-

* cecan@uns.ac.rs

party logistics services providers (taken from CSCMP), a large amount of heterogeneous data from different sources is required to determine logistic performance.

Logistics management is part of supply chain management (SCM) that plans, implements, and controls the efficient, effective forward and reverses flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements (taken from CSCMP). In modern business systems, competition is no longer between organizations, but among supply chains (SCs). Effective supply chain management has, therefore, become a potentially valuable way of securing a competitive advantage and improving organizational performance (Trkman et al. 2010). The most significant challenges for supply chain management involve the following: (i) providing visibility into supply chain performance and bench-marking; (ii) reducing operating costs through process optimization across the plan, source, make, and deliver functions; (iii) enhancing customer satisfaction by improving supply chain responsiveness and product quality (Genepakt, 2015).

Contemporary companies operate on a turbulent and very dynamic market. Under the influence of changes in business operations, primarily those caused by globalization and the increasingly shorter product life cycle as well as the requirements for product customization and sustainability, company supply chains are becoming more complex, more extended, and more global every day. Due to the increased uncertainty and competition, companies face challenges to improve operational efficiency and integrate production and distribution processes through different supply chain components. They are constantly on the lookout for new options and methods required for their logistics and supply chain management.

In the era of digitalization, due to the enormous amount of data generated on a daily basis, traditional knowledge and approaches cannot be used to manage logistics and supply chains. Web 2.0, together with Industry 4.0, cloud computing, the Internet of Things (loT), RFID and other digital technologies have led to generation, storage and transmission of large amounts of data. As the volume and complexity of data increases, so does the complexity and the time required to analyze those data and derive insight from them. In response to technological changes and changes in business processes, big data business analytics value is being increasingly studied and the application of various analytical techniques to decision making and problem-solving in business processes is being investigated. In supply chain management, there is a growing interest in business analytics as an approach that supports the efficient flow of materials along the supply chain. This is also called supply chain analytics (SCA). SCA refers to the use of data and quantitative tools and techniques to improve operational performance, often indicated by such metrics as order fulfillment and flexibility in supply chain management (Bongsug et al. 2014).

This paper aims to summarize the knowledge about supply chain analytics as a relatively new approach which, by better data management, enabled by the use of modern information and communication technologies, represents a new step towards efficient solutions in logistics and supply chains. The SCA is seen as a higher, more advanced level in the supply chain management which is accompanied by new challenges and opportunities in both business and IT. In addition, the paper examines to what extent the problems described here are studied within the university courses, i.e., what is the response of the university to the needs of the economy.

## 2. SUPPLY CHAIN ANALYTICS

The widespread use of digital technologies has led to the emergence of big data business analytics as a critical business capability to provide companies with better means to obtain value from an increasingly massive amount of data and gain a powerful competitive advantage (Wang et al. 2016). The study of big data is continuously evolving and the main attributes of big data have been characterized by what is called 5Vs concept consisting of: volume, variety, velocity, veracity, and value (Nguyen et al. 2018; Tiwari et al. 2018). Volume refers to the magnitude of data generated; the volume of digital data is growing exponentially and is expected to reach 35 Zeta bytes by 2020 (Arunachalam et al. 2018). Variety refers to the fact that data can be generated from heterogeneous internal and external sources, in structured, semi-structured, and unstructured formats (Nguyen et al. 2018). Velocity refers to the speed of data generation and delivery, which can be processed in batch, real-time, nearly real-time, or stream- lines (Nguyen et al. 2018). Veracity stresses the importance of data quality because many data sources inherently contain a certain degree of uncertainty and unreliability (Nguyen et al. 2018). Value refers to finding new value contained in the data which can be used for better business planning.

Big data analytics (BDA) involves the use of advanced analytics techniques to extract valuable knowledge from vast amounts of data with variable types in order to draw conclusion by uncovering hidden patterns and correlations, trends, and other business valuable information and knowledge, in order to increase business benefits, increase operational efficiency, and explore new market and opportunities (Nguyen et al. 2018; Tiwari et al. 2018). BDA is not new since various quantitative techniques and modeling methods have long been used in business processes (Souza, 2014). From 1950 to 2010, the complexity of data has increased gradually, and as a result, BDA has emerged as a flagship technology to tackle BD challenges (Arunachalam et al. 2018).

In recent decades, under the influence of technological development, globalization and increasingly demanding customers, new structures and strategies have been developed in the production, logistics and SCM. Business paradigms have also changed accordingly. This development is largely enabled by the revolutionary development of information and communication technologies. Figure 1 shows typical periods (with a brief description) in the evolution of logistics, SCM and BDA.

In accordance with the needs of modern business systems and with respect to the fact that logistics is the basic driver of SCs, improving the performance in these areas has become a continuous process that requires an analytical performance measurement system. Increasing logistics and supply chain efficiency begins with establishing, determining, and enhancing basic metrics and reporting, as they provide essential data for performance improvement initiatives. Nowadays the volume of data in every supply chain is exploding from different data sources, business processes and IT systems, including enterprise resource planning (ERP) systems, distributed manufacturing environments, orders and shipment logistics, social media feeds, customer buying patterns, and technology-driven data sources such as global positioning systems (GPS), radio frequency based identification (RFID) tracking, mobile devices, surveillance videos, and others (Editorial Board, 2018). Digitalization is present in all spheres of human activities and when it comes to business activities then digitalization is a personification of the concept Industry 4.0 (Maslarić et al. 2016). As the amount of data becomes larger, more diverse and more complex the need to manage and analyze them becomes more challenging in order to deliver useful business insights.

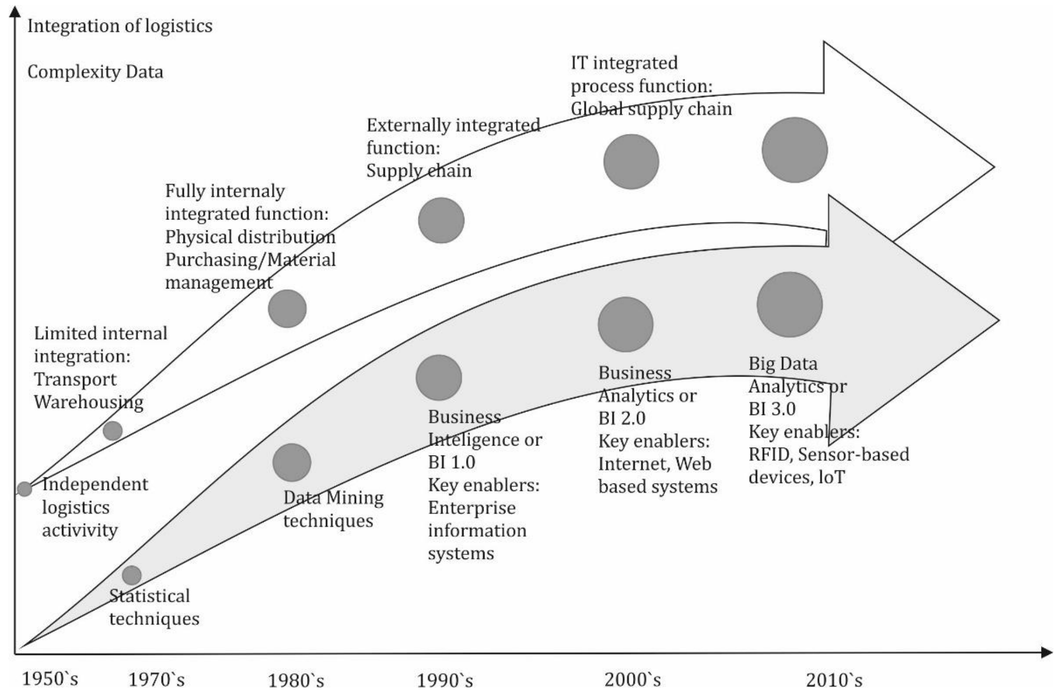


Figure 1. Evolution of logistics, SCM, and BDA (adapted from Arunachalam et al. 2018)

The business uncertainty (market conditions) is among the most important challenges facing modern SCs, and it poses considerable difficulties in terms of SC planning and control. All this has led to the growing interest in big data analytics in the management of logistics and supply chains i.e., for establishing supply chain analytics (SCA). SCA represents a more advanced level in the management of logistics and supply chains, not only as a way to improve performance but also to gain new knowledge. SCA represents a group of approaches, organizational procedures and tools, which are used together to get information, analyze this information and predict the outcome of solutions in different SC areas (adapted from Arunachalam et al. 2018). In the strategic phase of supply chain planning, SCA has been applied to help companies make strategic decisions on sourcing, supply chain network design, as well as on product design and development. In the operational planning phase, SCA has been used to assist management in making operation decisions, such as: demand planning, procurement, production, inventory, and logistics (Wang et al. 2016). The supply chain alone produces a large enough data set that analytics can be applied not only in reporting but also in better predicting of future challenges.

Supply chain analytics focuses on the use of information and analytical tools to make better decisions regarding material flows in the supply chain (Souza, 2014). Analytics techniques can be categorized into three types: descriptive, predictive, and prescriptive:

- Descriptive analytics describes what happened in the past and derives information from significant amounts of data to answer the question of what is happening. On the basis of real-time information about locations and quantities of goods in the supply chain, managers make decisions at the operational level (e.g. they adjust the schedule of shipments, deploy vehicles, issue orders for restocking products, etc.)

(Souza, 2014). Common examples of descriptive analytics are reports that provide historical insights regarding the company's production, financials, operations, sales, finance, inventory, and customers (Tiwari et al. 2018).

- Predictive analytics uses historical data to determine the probable future outcome. Predictive analytics in supply chains derives demand forecasts from past data and answers the questions related to what will be happening or what is likely to happen (Tiwari et al. 2018). It exploits patterns found in the data to identify future risks and opportunities and predict the future. This is used to fill in the information that is missing and to explore data patterns using statistics, simulation, and programming.
- Prescriptive analytics derives decision recommendations based on descriptive and predictive analytics models as well as on mathematical optimization, simulation or multi-criteria decision-making techniques. It goes beyond predicting future outcomes by also suggesting action to benefit from the predictions and showing the decision maker the implications of each decision option. Prescriptive analytics answers the question of what should be happening.

Statistical analysis, simulation, and optimization are popular techniques in SCA. In addition, we should also mention association rule mining, clustering algorithms, support vector machine, neural networks, fuzzy logic, text mining, sentiment analysis, feature selection, etc. (Tiwari et al. 2018).

## 2.1 Supply chain analytics in published papers

Since 2010 SCA has attracted a great deal of attention on behalf of academic and professional public. This is indicated by a large number of papers published in scientific journals and presented at conferences as well as by the results of research on the application of SCA in practice. The published papers deal with different aspects of SCA such as big data attributes, the influence of big data analytics on logistics and supply chain performance, and implementation issues and supply chain capability maturity with big data.

One of the first papers written on this topic is by Trkman et al. (2010). Their paper investigates the relationship between analytical capabilities in the plan, source, make and delivery area of the supply chain (based on the Supply Chain Operations Reference model - SCOR) and business process orientation as moderators. The results provide a better understanding of the areas where the impact of business analytics may be the strongest. Bongsug et al. (2014), approach SCA as an integration of three types of resources: data management resources, IT-enabled planning resources and performance management resources and investigate the relationships between these resources and supply chain planning satisfaction and operational performance. The findings of their research offer vital information towards a better understanding of the role of business analytics for supply chain management and its impact on operational performance. Wang et al. (2016) assess the extent to which SCA is applied for the management of logistics and supply chains depending on the maturity of the SCA. They emphasize SCA's strategic importance as an asset that enables integrated business analytics of the company.

Several papers have also been published so far that provide an overview and systematization of academic literature on big data analytics and supply chain. Tiwari et al. (2018) investigate big data analytics research and application in supply chain management between 2010 and 2016 and provide insights to industries. In terms of future research in this field, a paper by Nguyen et al is particularly interesting as it proposes a novel classification framework that provides a full picture of current literature on where and how BDA has been applied within the SCM context (Nguyen et al. 2018). A critical review of the literature written by Arunachalam et al. (2018), is focused on understanding the multiple dimensions of BDA capabilities in the supply chain. The paper presents a conceptual model of maturity that explains five dimensions of BDA capabilities: data generation capability, data integration and management capability, advanced analytics capability, data visualization capability, and data-driven culture.

Traditionally, supply chains have been managed by transactional systems, like ERP/SCM systems which are meant to run operations in an automated fashion, not to analyze data for predictive insights. These transactional systems are significant components of SCA, which may have contributed to the fact that in practice the ability to report is frequently wrongly identified as analytical ability. The fact is that there are many levels of analytics covering a whole spectrum of capabilities from standard reporting and alerts all the way to statistical analysis, forecasting, predictive modeling, and optimization.

By applying SCA companies strive to achieve different goals. The results of a survey carried out by APQC which included experts in the supply chain from 36 sectors show that companies have several areas that they focus on in SCA application (Figure 2). In addition to supply chain performance improvement, organizations are looking at analytics as a means of better dissemination of information. According to the results of this survey, descriptive analytics is most widely used in all areas of the supply chain, predictive analytics is used less for certain functions (for the functions of supply chain planning and procurement), while prescriptive analytics is used to a lesser extent (APQC).

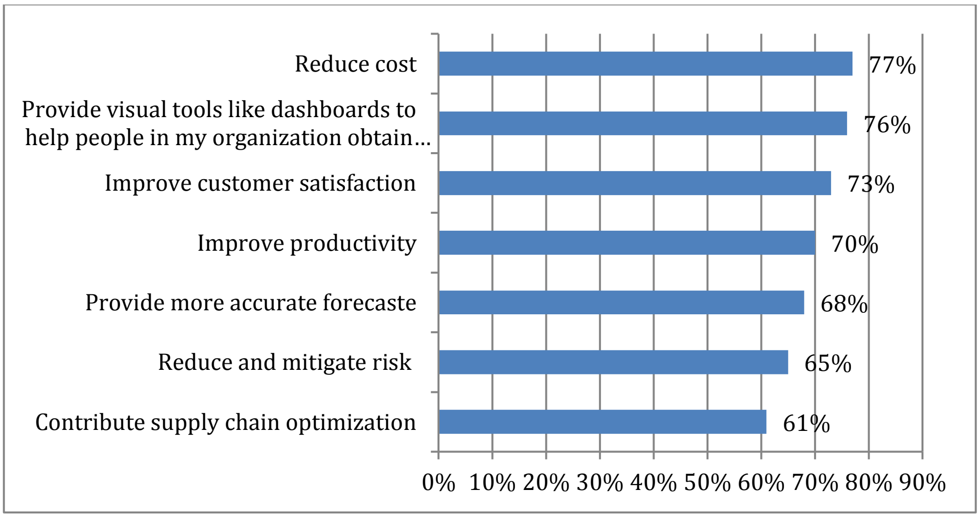


Figure 2. Areas of focus for supply chain analytics (APQC, 2017)

Nguyen et al. (2018) considered in their work, among other things, the representation of different types of analytics in published scientific papers (the review covered 88 papers) and concluded that prescriptive analytic was most often discussed, as shown in Table 1.

Table 1. Level of analytics in each SC function (Nguyen et al. 2018)

| | Descriptive | Predictive | Prescriptive | **Total papers** | In % |
|---|---|---|---|---|---|
| Procurement | 3 | 5 | 2 | 10 | 11.36 |
| Manufacturing | 4 | 7 | 12 | 23 | 26.13 |
| Warehousing | 3 | 3 | 6 | 12 | 13.64 |
| Logistics/transportation | 4 | 6 | 15 | 25 | 28.41 |
| Demand management | 2 | 10 | 0 | 12 | 13.64 |
| Other SC topics | 2 | 0 | 4 | 6 | 6.82 |
| **Total papers** | 18 | 31 | 39 | 88 | 100.00 |
| In % | 20.45 | 35.23 | 44.31 | 100.00 | |

## 2.2 Supply chain analytics in university curricula

Supply chains are becoming more complex, more extended, and more global every day so that adequate logistics are needed for logistics and supply chain management and their adjustment to business changes. Creation and implementation of educational programs, which besides traditional knowledge from logistics and SCM include contemporary topics in this field (which are caused by technical, technological and business changes), presents the challenge and challenge for universities and their response to the demands of the economy. SCA is one such topic. In this paper, a short study of curricula at EU universities related to SCA was conducted.

As SCA presumes that the students possess an appropriate level of knowledge in the areas of logistics, SCM and mathematics, and that SCA enables the acquisition of new knowledge and skills, it is planned that the research focuses on master and doctoral studies at European universities. The search was carried out over the Internet using the following key words: master in logistics, and master supply chain management. In this way, a list of 45 faculties in Europe that has master studies in logistics and/or supply chain management has been obtained (taken from Masterstudies.com). The structure of the subject in master studies for all selected faculties is reviewed, and analyzed. The results thus obtained are shown in Table 2. It can be concluded that at European faculties with master studies of logistics and supply chain management, about 50% of them there is a subject SCA, other related subjects or SCA master's program. The same procedure was applied for the level of doctoral studies, however, obtaining valid data, because of the specificity of organizing this level of study, requires a different approach, so in this paper, this area has not been processed.

Study programs at the master level in the Republic of Serbia are reviewed by the Universities of Belgrade (Faculty of Transport and Traffic Engineering, Faculty of Economics, Faculty of Mechanical Engineering, Faculty of Organizational Sciences), Novi Sad (Faculty of Technical Sciences, Faculty of Economics), and Niš (Faculty of Economics, Faculty of Mechanical Engineering). Only at master studies at the Faculty of Transport and Traffic Engineering, there are related subjects with SCA (on the other faculties there are not related subjects with SCA). It should be noted that at the Faculty of Organizational Sciences there is master’s program Business analytics.

Table 2. SCA subjects to master studies at European faculties

| | Number of faculties | In % |
|---|---|---|
| No data | 5 | 11.11 |
| There is not SCA master's program | 18 | 40.00 |
| There are related subjects | 18 | 40.00 |
| There are a subject SCA and other related subjects | 2 | 4.44 |
| There is SCA master's program | 2 | 4.44 |
| Total faculties | 45 | |

Considering the wide scope of logistics and SCM, a positive response from the European faculties to the requirements of training in the logistics of logistics managers from the Big Data analytics and supply chain can be noted. It should be the guideline of faculties in the Republic of Serbia.

## 3. CONCLUSION

Data analysis is crucial for decision-making in all business applications. At the time of digitalization the volume of data in every supply chain is exploding from different data sources, business processes, and IT systems. Big data analytics uses more sophisticated computational techniques to handle complex data that has been increasing on a large scale, and unable to be processed using traditional methods. In logistics and supply chain management, there is growing interest in business analytics based on big data.

A brief overview of the papers showed the great interest of scientists to understand the various aspects of SCA in the management of logistics and supply chains. Surveys in practice show that companies expect from SCA better predictions and thus respond to them proactively, increasing both efficiency and profitability. Obviously, this topic will be much more explored.

Research of SCA curricula at universities in Europe has shown their positive response to the requirements of practice in the field of education of logistics and supply chain managers in this field. It should be the guideline of faculties in the Republic of Serbia.

## ACKNOWLEDGMENT

The study was financially supported by the Serbian Ministry of Education and Science (Project No. TR36030).

## REFERENCES

[1] APQC: Maturity is key to analytics effectiveness, Supply Chain Management Review, Maz June, 2017, 56-59, https://www.apqc.org/knowledge-base/documents/maturity-key-analytics-effectiveness, (01. 03. 2019).

[2] Arunachalam, D., Kumar, N., Kawalek, J. P. (2018). Understanding big data analytics capabilities in supply chain management: Unravelling the issues, challenges and implications for practice, Transportation Research Part E, 114, 416-436.

[3] Chae, B. K., Olson, D., Sheu, Ch. (2014). The impact of supply chain analytics on operational performance: a resource-based view. International Journal of Production Research, 52 (16), 4695–4710.
[4] CSCMP, https://cscmp.org/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms/CSCMP/ Educate/SCMDefinitions_and_Glossary_of_Terms.aspx?hkey=60879588-f65f-4ab5-8c4b-6878815ef921, (04. 03. 2019).
[5] Editorial Board (2018). Big data analytics and application for logistics and supply chain management. Transportation Research Part E, 114, 343-349.
[6] GENEPAKT (2015): Driving supply chain excellence through Data-to-Action Analytics, https://www.genpact.com/downloadable-content/insight/driving-supply-chain-excellence-through-data-to-action-analytics.pdf, (01. 03. 2019).
[7] https://www.genpact.com/downloadable-content/insight/driving-supply-chain-excellence-through-data-to-action-analytics.pdf (01. 03. 2019).
[8] Maslarić, M.; Nikoličić, S.; Mirčetić, D. (2016). Logistics Response to the Industry 4.0: the Physical Intenet, Open Engineering, 6 (1), pp. 511-517.
[9] Masterstudies.com. https://www.masterstudies.com/search/?q=faculty+in+Europe+master+supply+chain+and+logistics&filter=all. (01. 03. 2019).
[10] Nguyen, T., Zhou, L., Spiegler, V., Ieromonachou, P., Lin, Y. (2018). Big data analytics in supply chain management: A state-of-the-art literature review. Computers and Operations Research, 98, 254-264.
[11] Souza, G. C. (2014). Supply chain analytics. Business Horizons, 57, 595-605
[12] Tiwari, S., Wee, H.M., Daryanto, Y. (2018). Big daBig data analytics in supply chain management between 2010 and 2016: Insights to industries. Computers & Industrial Engineering, 115 319-330.
[13] Trkman, P., Mc Cormack, K., de Oliveira, M. P. V., Ladeira, M. B. (2010). The impact of business analytics on supply chain performance. Decision Support Systems, 49, 318–327.
[14] Wang, G., Gunasekaran, A., Ngai, E. W. T., Papadopoulos Th. (2016). Big data analytics in logistics and supply chain management: Certain investigations for research and applications. Int. J. Production Economics, 176, 98-110.