A Classification Predictive Model to Analyze the Supply Chain Strategies

Elena PUICA
Economic Informatics Doctoral School,
Bucharest University of Economic Studies, Bucharest, Romania
elenaa.puica@gmail.com

Big Data Analytics (BDA) has the capacity to increase communications and better manage supply chain strategies. The main objective of this study developed, firstly was a systematic literature review, to understand how BDA has been investigated on supply chain strategies, which resources are handled by BDA and which Supply Chain Management strategies are positively affected by those technologies, and secondly, to apply a classification predictive model to foresee the level of implementation of innovative technologies in supply chain strategies. The applied predictive classification model helped to offer an understanding and to determine that in supply chain strategies there are innovative technologies implemented and their percentage of implementation will have an increasing value. This study, that is focused on BDA and supply chain strategies, offers new opportunities, and is adding value and operational excellence for existing supply chain practices. The adoption of big data technology in supply chain can create considerable value-added.
Keywords: *Supply Chain Strategy, Big Data Analytics, Big Data Analytics in SCM, Classification Predictive Model, Supply Chain Management*
DOI: 10.24818/issn14531305/25.2.2021.03

1 Introduction

Enhancement of information technology, increasing client's hopes, globalization, economic, and the other innovative competitive significances have pushed Supply Chain Management (SCM) to transform and adapt. Consequently, competition between enterprises is replaced by competition between enterprises and their SCM. In competitive environment generated, the supply chain professionals are battling in managing the huge data to achieve integrated, effective, efficient, and agile SCM. Explosive increase in volume and various types of data in SCM has produced the demand to build technologies that can smartly and quickly examine significant amount of data. Big data analytics (BDA) capability is one of the techniques, that can help enterprises to overcome challenges that may encounter. BDA offers a tool for obtaining valuable patterns and information in large volume of data. Supply chain expression is used in different ways, three meanings dominate: "supply chain" from the viewpoint of an individual firm; "supply chain" associated to a certain product or item; and "supply chain" utilized as a synonym for purchasing, distribution, and materials management.[1] SCM can mean any one of these things, but one aspect is certain: Purchasing and/or outsourcing activity is being undertaken.[2] SCM is an consolidative viewpoint used to handle the total flow through a distribution channel from the supplier to the ultimate user [3] [4]. Another definition is the management of a chain or of operations and centers through which supplies move from the source of supply to the final customer or point of use [5]. Fundamentally, the supply chain starts with the extraction of raw material, and each link in the chain processes the material or the concept in some way or supports this processing. The supply chain thus extends from the raw material extraction or raw concept origination through many processes to the ultimate sale of the final product, whether goods or services, to the consumer.

Analyzing and understanding the outcomes in real time can lead to make making better and quicker decisions to meet the customer requirements, and it will lead to the improvement of supply chain design and management by reducing costs and mitigating risks. Use of data science, predictive analytics, and big data could help logistics managers to meet internal needs and adjust to changes in the supply chain environment [6] [7].

The remainder of this paper is structured in three main sections, an introduction, and a conclusion. The first section of this paper reviews relevant Supply Chain Strategy literature and the studies related to the practices and classification of supply chain strategy, in section two is presented Big Data Analytics and its impact in Supply Chain Management Strategy, with examples of strategies integrated with Big Data Analytics. Section 3 details the model applied to analyze the level of implementation of innovative technology in supply chain strategy and presents the results of classification predictive model analyses. The paper is finalized with the conclusions.

2 Supply Chain Management strategy

SCM is becoming more dynamic and encompasses the continuous stream of data, funds, and product between different stages of the processes. Each phase in a SCM is linked across the flow of information, products, and funds. These movements regularly appear in both routes and may be handled by one of the phases or an intermediary. Supply chain design, planning, and operation judgments perform a considerable role in the success or failure of an enterprise. For remaining competitive, SCM need to adjust to the shifting technology and client's beliefs, a successful SCM involves numerous decisions concerning the flow of product, information, and funds.

2.1. Supply Chain Strategy & Design: the company determines how to shape the SCM over the following years (configuration, allocation of the resources, and the processes involved). Strategic decisions contain whether to outsource or to perform a SCM function in-house, the location and dimensions of production and warehousing conveniences, the products to be manufactured or deposited at various places, the type of transportation, and what type of information system to operate. Supply chain design decisions are usually prepared for long term periods of time.

2.2. Supply Chain Planning: The SCM's configuration formed in the strategic stage is fixed and establishes constraints within which planning must be completed. Planning establishes parameters within which a supply chain will function over a specified period. The planning stage begins with a forecast for the next year of demand and other factors such as costs and prices in different markets. Because of the planning stage, enterprises define a set of operational procedures that regulate short-term operations.

2.3. Supply Chain Operation: During this stage, enterprises make judgments concerning individual client's orders. The main objective of supply chain operations is to handle incoming customer orders in the best potential way. In this stage, enterprises allocate inventory or production to single orders, establish a date that an order is to be filled, create pick lists at a warehouse, allocate an order to a specific shipping shipment and mode, establish delivery schedules of trucks, and place replenishment orders. Because of the limitations formed by the configuration and planning guidelines, the objective during the operation stage is to exploit the reduction of ambiguity and optimize performance.

SCM is a series of processes and flows that take place within and among different phases and come together to fill a customer need for a product. SCM processes can be categorized into Supplier Relationship Management (SRM), focused on the interface between the enterprise and its suppliers, Internal Supply Chain Management (ISCM), internal processes for the enterprise and Customer Relationship Management (CRM), focused on the interface between the enterprise firm and its customers. These processes control the flow of data, product, and funds expected to generate, receive, and fulfil a customer request. CRM generates customer demand and facilitate the placement and tracking of orders, ISCM fulfils demand generated by the CRM process in a timely manner and at the lowest possible cost and SRM arranges and manages supply sources for various goods and services. For a SCM to be successful, it is important that the three processes are properly integrated. (e.g.: Figure 1)

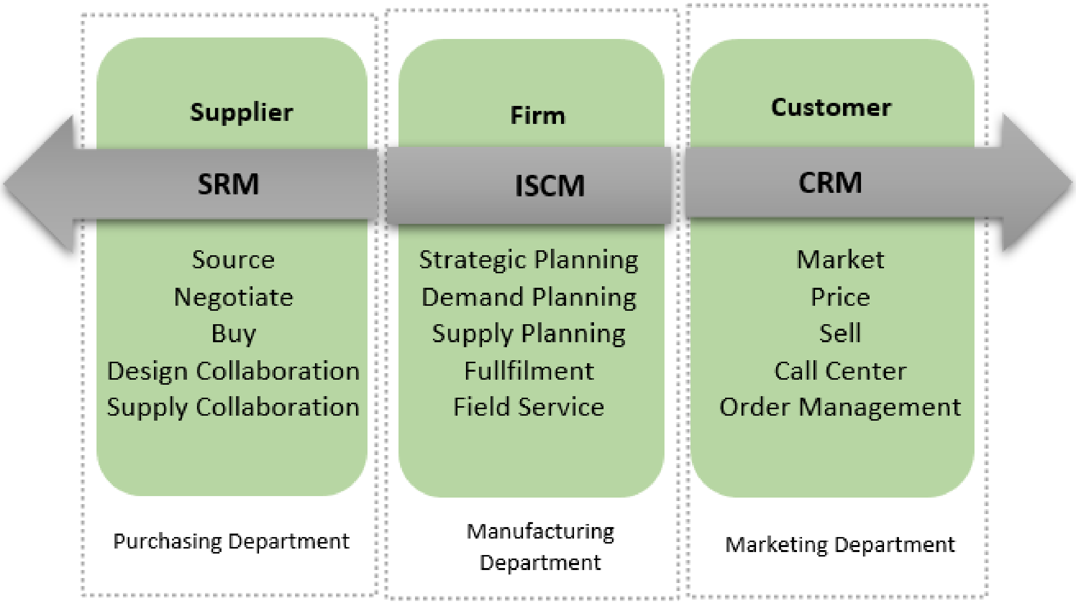

Fig. 1. Supply chain processes classification and attributes

A supply chain strategy controls the nature of procurement of raw materials, transportation of materials within the company, manufacture of the product or operation to deliver the service, and distribution of the product to the customer, along with any follow-up specification whether these processes will be performed in-house or outsourced. Supply chain strategy as well contains design decisions about inventory, transportation, operating facilities, information flows, pricing, and sourcing. The supply chain strategy establishes how the SCM must operate with respect to efficiency and responsiveness (e.g.: Figure 2).

a. Facilities are important for SCM performance in terms of responsiveness and efficiency, and they are a crucial part of supply chain design.

b. Inventory impacts the assets held, the costs incurred, and responsiveness provided in the SCM. Inventory also has a significant impact on the material flow time in a supply chain.

c. Transportation transfers the product between different phases in a SCM and impacts responsiveness and efficiency. The type of transportation that is used affects the inventory and facility locations in the SCM and allows a firm to adapt the location of its facilities and inventory to get the right equilibrium between responsiveness and efficiency.

d. Information can help increase the utilization of SCM assets and the coordination of the flows to improve responsiveness and reduce costs. The appropriate investment in information technology increases visibility of transactions and synchronization of decisions within the SCM.

e. Sourcing is the set of processes needed to purchase goods and services. Sourcing decisions have a substantial impact on SCM performance.

f. Pricing includes the process of the decisions on how much a customer will be charged for its goods and services. Pricing influences the customer divisions, that choose to buy the product, and the customer's expectations.

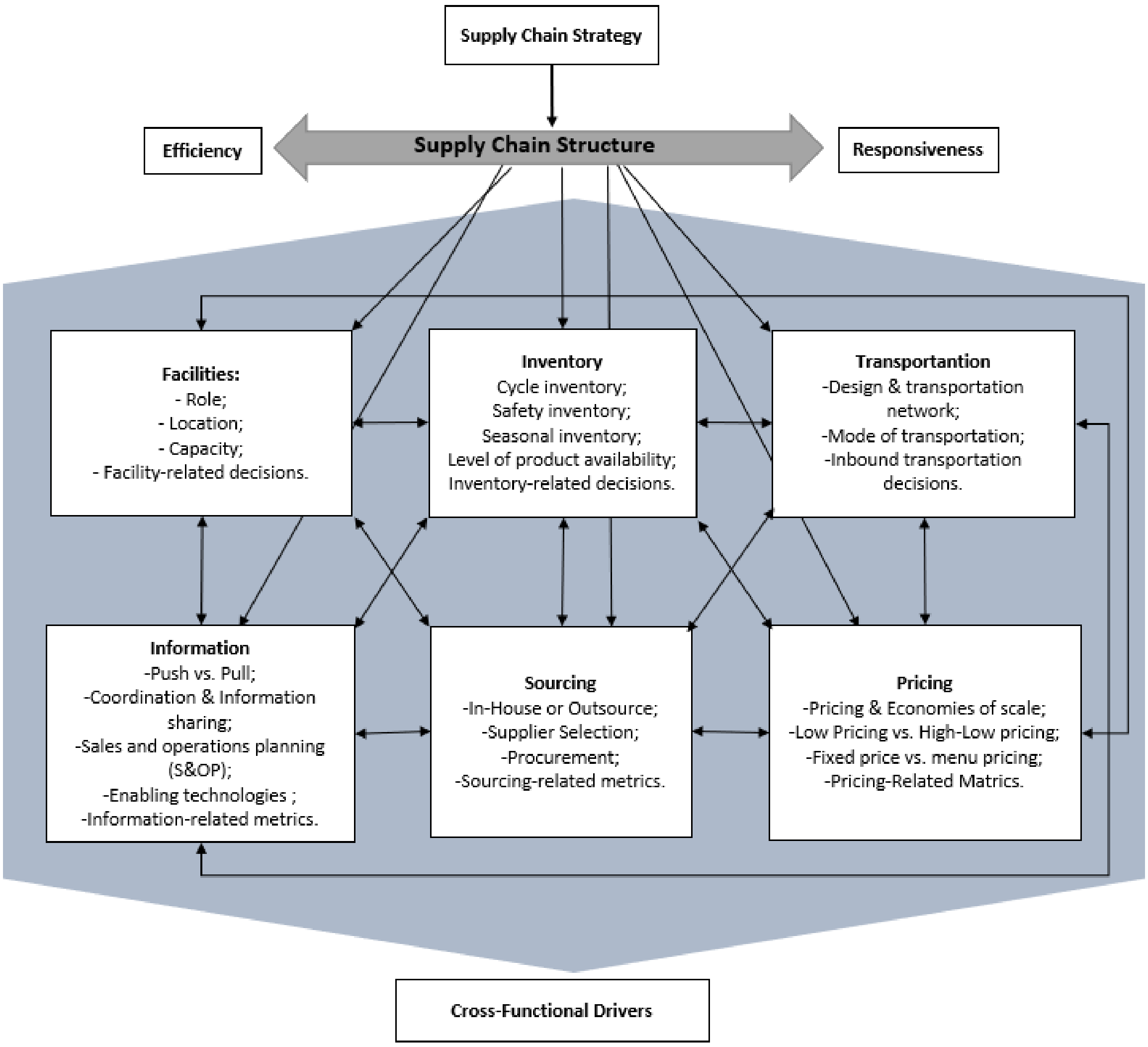

Fig. 2. Supply Chain Decision Making Framework

BearingPoint supports customers in the development of superior supply chain strategies, these strategies are the operational strategy, which help companies identify the optimal positions of working capital, costs, and service levels. Outsourcing, focusing on core competencies minimizes efforts for non-core activities and drives efficiency. Labor and force optimization, operational locations use performance metrics to plan activities, benchmark internal performance versus other locations, manage staff, and decide on individual compensation. Reviewing how this information is utilized enables companies to identify ineffective or inaccurate performance metrics, which may result in reduced productivity, ineffective planning, and scheduling activities, as well as misleading comparisons being drawn between locations. Inventory performance management, controlling inventory levels and analyzing the root causes of poor inventory performance. Network strategy and design, the goal of strategic design and optimization of supply chain networks is to find an optimally balanced and robust structural solution for the trade-offs of low cost, excellent service, and minimal inventory. Risk management, to reduce risk exposures through solid management rules, which create a standardized and sustainable approach. Predictive supply chain analytics and diagnostics, discovering hidden insights and relationships to derive relevant implications as early as possible. Product configuration analytics, by providing new tools to innovate, especially a client's product sales processes and product management. (e.g.: Figure 3)

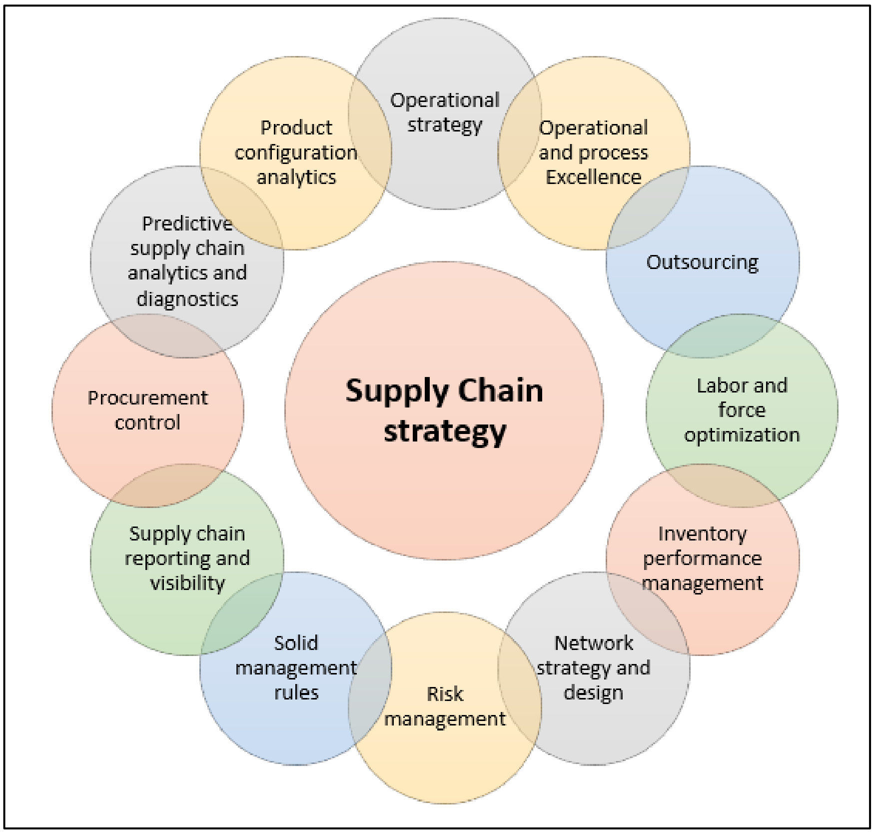

Fig. 3. Supply Chain Strategy according to BearingPoint

***Source*: Own processing with data from Bearing Point site https://www.bearingpoint.com/ro-ro/our-expertise/capabilities/operations/supply-chain-strategy-and-network/**

3 Big Data Analytics in Supply Chain Management Strategy

SCM involves utilizing BDA techniques to find obscured valuable understanding from supply chain [8]. BDA techniques can be categorized into descriptive, predictive, and prescriptive analytics [9].

Applying BDA techniques to solve SCM challenges has a positive and considerable impact on supply chain performance. Supply chain professionals and representative researchers have applied operational and statistical research techniques to unravel supply and demand assessing problems. [10] The interactions between descriptive, predictive, and prescriptive analytics to make decisions or take actions is presented in Figure 4.

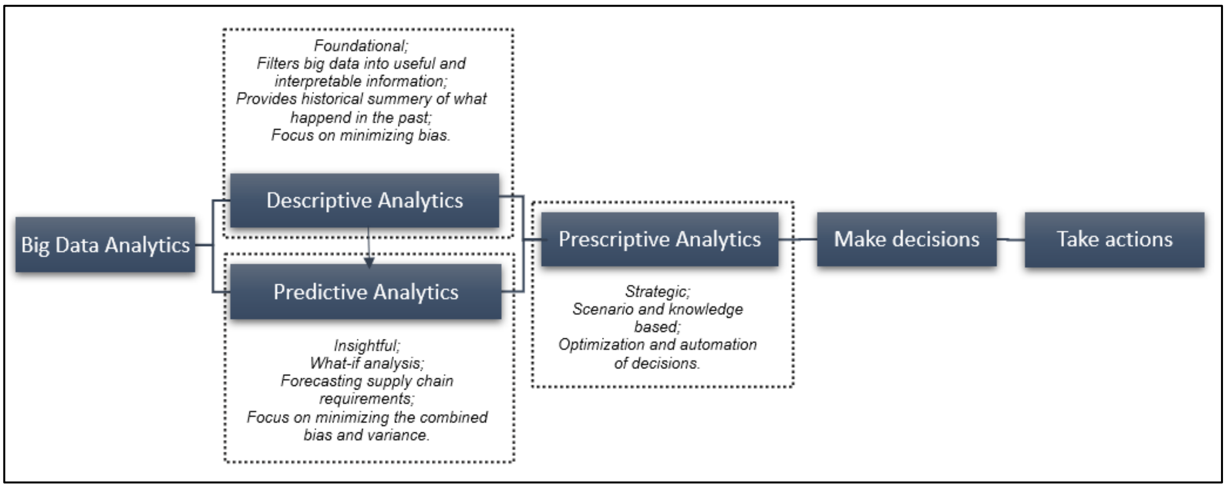

Fig. 4. Using descriptive, predictive, prescriptive analytics to make decisions and to take actions.

In the production area, a significant volume of data is created by internal networks that include sensor networks or equipment on the production floor and by external channels. Applying BDA, it can enhance the efficiency of the distribution together with sales process and to continuously monitor processes and devices involved. The various number of vendors and the multiplicity of their evaluation and selection indicators, the selection process of the right and optimal vendor for the SCM is challenging, BDA techniques give valuable understanding to select the best suitable vendors. BDA can be used in numerous areas of SCM, in the next sections, a synopsis of BDA applications in different areas of SCM is offered [11].

3.1. Big Data Analytics and SRM

Creating close relations with key suppliers and improving the cooperation with them is a crucial factor in determining and creating new value and lowering the risk of failure in SRM. Using BDA techniques can offer precise information on organizational expenditure patterns that help to manage supplier relationships [12].

3.2. Big Data Analytics and Supply Chain Network Design

Is a strategic decision, that involves all decisions concerning the selection of business partners and describes company procedures to accomplish long-term strategic targets. Supply chain network design project includes deciding supply chain physical configuration that influences the business units or functional areas. The aim of supply chain design is to create a network of members that can meet the long-term strategic targets established. The following steps must be followed when designing a supply chain: define the long-term strategic targets; define the project scope; determine the form of analyses; determine the tools that will be used; and project completion.

3.3. Big Data Analytics and product design and development

Designers need instruments to predict and measure the preferences and expectations of the customers, it needs the be considered that a lack of enough information about customers' is a critical issue in the product design process. By continuously monitoring the customer behaviour and preferences, a better design of products can be achieved. Collecting, managing a high volume of data, and applying new analytical techniques lead to valuable insights and valuable information that can reduce uncertainty [13]. Supply chain design according to product design creates competitive advantage and flexibility in the supply chain [14]. Designers can use online behavior and customer purchase record data to predict and understand the customer needs [15]. The goal of companies producing consumer durables is to maintain their competitiveness over the longest possible period [16].

3.4. Big Data Analytics and demand planning

A numerous number of SCM executives are eager to develop demand forecasting and production planning with BDA [17]. Precise demand forecast has always been a key puzzle in SCM [18]. A challenge that the enterprises face is the capability to apply advanced software, hardware and algorithm architecture [19]. BDA permit to recognize new market trends and determine root causes of issues, failures, and defects and can predict customers' preferences and needs by examining customer behavior [20].

3.5. Big Data Analytics and procurement management

Supply chain analytics can be applied to control suppliers' performance and supply chain risk with the use of external and internal big data [21]. Applying a framework to identify supply chain risk enables real-time risk management monitoring, decision support, and emergency planning [22].

3.6. Big Data Analytics and customized production

With BDA, manufacturers can discover new information and identify patterns that enable them to improve processes, increase SCM efficiency, and identify variables that affect production. Data analytics allows manufacturers to precisely determine each person's activities and tasks of each part of the production process and examine entire SCM in detail, which can allow manufacturers to recognize bottlenecks and reveal poorly performing processes and components. BDA have made it possible to precisely predict customer demands and preferences for customized products.

3.7. Big Data Analytics and inventory management

Big data create substantial competitive advantage by linking and combining internal production system with external partners in inventory management. Below are some ways that BDA is changing the way enterprises handle inventory:

a) Improved operational efficiency.
b) Increased customer service satisfaction.
c) Maximized sales and profits.
d) Reduced costs by migrating to the cloud.

3.8. Big Data Analytics and logistics

The logistic industry has faced a major transformation due to the occurrence of significant volumes of data and devices and rise of new technology. Since high volumes of data such as size, weight, origin, and destination are being produced daily, there is a huge potential for new business creation and operational efficiency and customer experience improvement. BDA have been used to gain competitive advantage and provide new services in logistics [23].

4 An analysis of supply chain with Classification Predictive model

Predictive Classification technique of SAP Analytics Cloud predicts the probability that an event happens. The principle of the classification engine of Smart Predict is to discover the best function capable to distinguish between examples that belong to a class.

4.1. Data collection and preparation

The data that was collected is structured (spreadsheets) and it was extracted data from the Eurostat database from 15 European Union Countries. Eurostat is the statistical office of the European Union, is a world-leading database widely known for its extensive, reliable content and high-quality statistics and data on Europe.

The data is composed of the technological innovations in the supply chain, as well as their percentage of applicability, but also the reason and the percentage of their implementation. To build the classification predictive model, the most common supply chain strategies were considered, these strategies are redesign of shipment, inventory management systems, digital supply chain management and E-procurement. For these four supply chain strategies, the data was extracted from fifteen

European countries. For each strategy, firstly, the average applicability percentage for the European countries was determined, and secondly, was identified the maximum value in each country of the applicability percentage of the strategies, followed by the calculation of the average for the maximum value. To create the best possible quality model, several variables were added in the construction of the module, for example, the reason why technological innovations were applied in supply chain strategies. Those reasons are to responding to cost pressures, improving enterprise's performance, opening new market opportunities, and responding to market pressures. For these four reasons mentioned, the percentage of the reason for their implementation was calculated and, firstly, the average percentage of applicability for European countries was calculated, and secondly, the maximum value in each country of the percentage of applicability of the strategies was identified, followed by calculating the average for the maximum value.

4.2. Modelling

The predictive goal is the technology innovation usability percentage value will likely be equal or more than the average of maximum value (13,5%). To identify if the classification predictive model has a high quality and robustness, two indicators should be determined, Prediction Confidence which measures the robustness of the model and Predictive Power which measures the quality of the model. These two indicators are subtracted based on the graph shown in Figure 5.

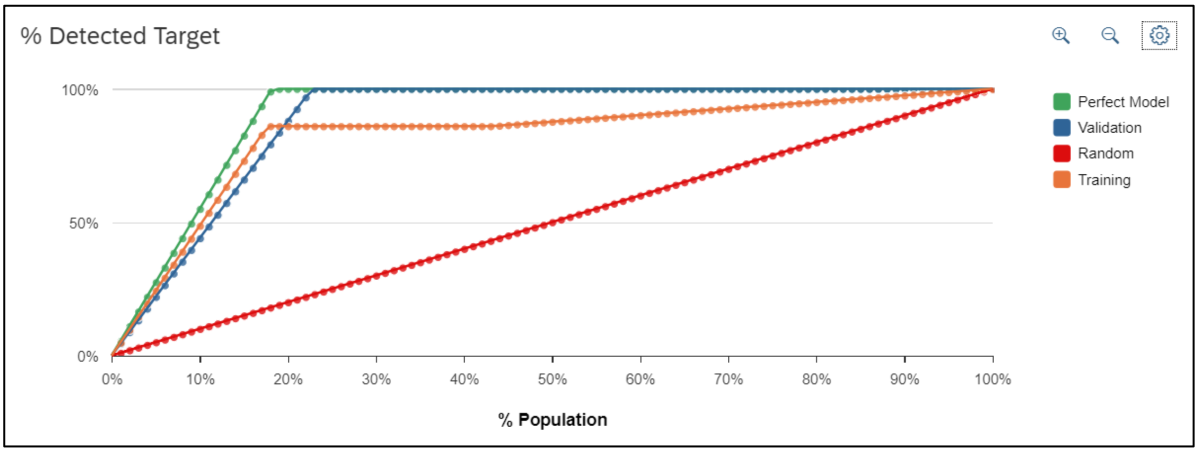

Fig. 5. Percentage of detected target / Percentage population

The red line is randomly picked by the model, which is a representation that there is no predictive model. The green curve exemplifies a hypothetical perfect predictive model, while the blue and orange curves relate to two data partitions of the generated model, training and validation.

The Predictive Power indicator measures how close to the ideal model the predictive model is. Area among Validation and Random curves divided by the area between Perfect and Random curves. The role of the Predictive Power is to give an idea of the quality of the predictive model. Prediction Confidence expresses the ability to reproduce the same detection with a new dataset. A « validation sample » is necessary to estimate it. The role of the Prediction Confidence is to measure if the predictive model can do the predictions with the same reliability when new cases arrive. If these new cases look like cases of the training dataset, then the Prediction Confidence will be good. The model that was trained for this study has the result of Predictive Power indicator 94,44% and the Prediction Confidence indicator 80,51%. (e.g.: Figure 6).

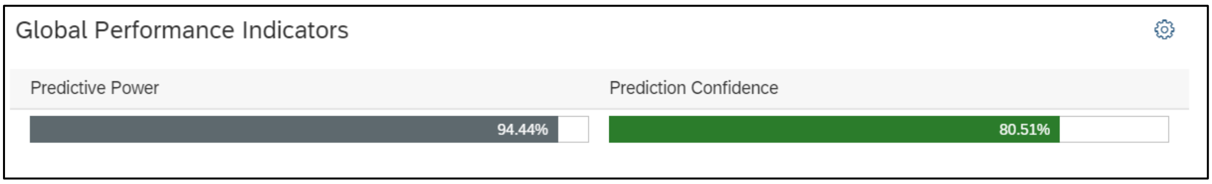

Fig. 6. Performance indicators

Another significative part of the report of a predictive classification model in SAP Analytics Cloud is the contributions of variables that were trained in the model. Contribution variables are displayed sorted by decreasing importance, and the most contributively ones are the ones that best explain the target variable. The sum of all contributions influencers equals always 100%. In the model applied the most contributively variables are the technology innovation with a percentage of 69,17%, the percentage of reason of implementation with a value of 23,78% and the reason of implementation with an implication of 5,27% (e.g.: Figure 7).

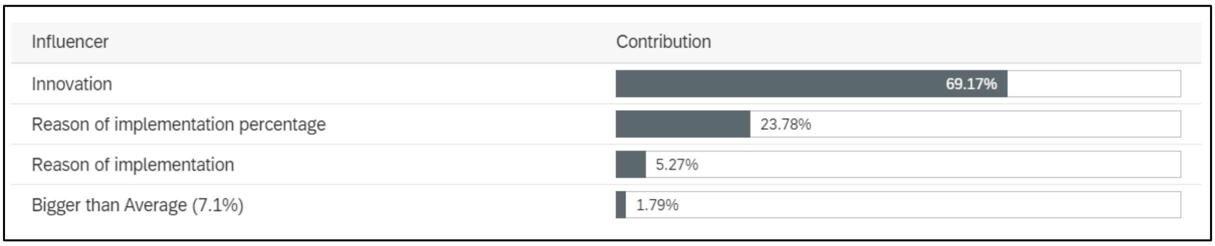

Fig. 7. Influencer contribution

4.3. Evaluation

Before proceeding to final deployment of the model, it is important to evaluate the model more thoroughly. The figure above shows the statistical results of the applied predictive classification model. The results from the Training section compared to the Validation section show that the percentage of application of innovations in supply chains is higher, which means that "Yes", more innovations will have the value equal or more than the average of maximum value (13,5%). (e.g.: Figure 8).

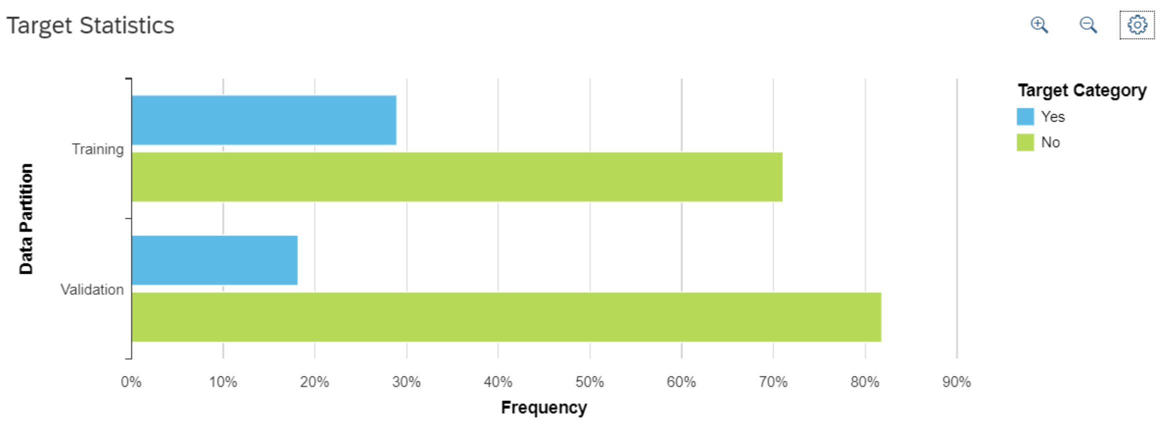

Fig. 8. Statistic results of the model, graphic representation

Figure 9 shows the statistical results of the classification predictive model applied, for the Training partition, category "Yes", a percentage of 28.95%, more innovations will have the value equal to or greater than the average of the maximum value (13.5%). On the other side, in the Validation partition, for the same category, 18.18% will have the value equal or higher than the average of the maximum value (13.5%). Focusing on the category "No", which indicates that innovation technologies in supply chain strategy will not have the value equal or more than the average of maximum value (13.5%), the results for Training partitions show a percentage of 71.05%, and the results for the Validation partition, show aa result of 81.83%. (e.g.: Figure 9)

Data Partition	Target Category	Frequency
Training	Yes	28.95%
Training	No	71.05%
Validation	Yes	18.18%
Validation	No	81.82%

Fig. 9. Statistic results of the model, detailed representation

The applied predictive classification model added to the literature an understanding of the innovative technologies associated with SCM strategies and determined that there are innovative technologies, and more than a quarter of the countries analyzed where the percentage of their implementation in supply chain will have the value of adopting innovative technologies that is equal, or more than the average of maximum value (13, 5 %).

5 Conclusions

There are many scopes for advancement in the application of most appropriate analytic techniques in era of SCM. This study tries to show some of the most essential and latest applications of innovative technology within the SCM strategies. BDA is also used in a range of activities which support the supply chain, including supplier relationship management, product design, development, demand planning, inventory, network design, production, procurement, logistics and distribution. There are several crucial applications across the end-to-end SCM, taking in consideration that is applied in various strategies of SCM, including the demand data at the sales department, retailer data, delivery data, manufacturing data, and until supplier data. By applying big data sources and analytics techniques in supply chain strategy led to various improvements, expansion, and developments. Additionally, BDA can sustain the development and improvement of responsive, reliable, and/or sustainable strategies of SCM and can be able to operate and incorporate massive sets of different data in a complex global SCM.

References

[1] MB. Arias, S. Bae. *Electric vehicle charging demand forecasting model based on big data technologies*. Applied Energy. 2016; 183:327-339

[2] AB. Ayed, MB. Halima, AM. Alimi. *Big data analytics for logistics and transportation*. In: 2015 4th International Conference on Advanced Logistics and Transport (ICALT). IEEE; 20 May 2015. pp. 311-316

[3] A. Balar, N. Malviya, S. Prasad, A. Gangurde. *Forecasting consumer behavior with innovative value proposition for organizations using big data analytics*. In: 2013 IEEE International Conference on Computational Intelligence and Computing Research. IEEE; 2013. pp. 1-4

[4] CW. Chase Jr. *Using big data to enhance demand-driven forecasting and planning.* The Journal of Business Forecasting. 2013;32(2):27

[5] CIPS. (1997). *Supply chain management: Technical services guide*. Easton, UK: Chartered Institute of Purchasing & Supply

[6] K. Compton, & D. Jessop, D. (1995). *Dictionary of purchasing & supply*. Easton, UK: CIPS.

[7] L. Ellram. (1990, Fall). *Supplier selection in strategic partnerships.* Journal of

Purchasing and Material Management, 8-14.
[8] H. Hassani, ES. Silva. *Forecasting with big data: A review*. Annals of Data Science. 2015; 2(1):5-19
[9] M. Johanson, S. Belenki, J. Jalminger, Fant M, Gjertz M. *Big automotive data: Leveraging large volumes of data for knowledge-driven product development.* In: 2014 IEEE International Conference on Big Data (Big Data). IEEE; 2014. pp. 736-741
[10] O. Khan, M. Christopher, A. Creazza. *Aligning product design with the supply chain: A case study.* Supply Chain Management: An International Journal. 2012; 17(3):323-336
[11] J. Leveling, M. Edelbrock, B.Otto. *Big data analytics for supply chain management*. In: 2014 IEEE International Conference on Industrial Engineering and Engineering Management. IEEE; 9 Dec 2014. pp.918-922
[12] Y. Li, MA. Thomas, KM. OseiBryson. *A snail shell process model for knowledge discovery via data analytics*. Decision Support Systems. 2016; 91:1-2
[13] D. Macbeth, N. Ferguson, G. Neil, & L. Baxter. (1989, November). *Not purchasing but supply chain management*. Purchasing and Supply Management, 30-32
[14] S.J. New, (1997). *The scope of supply chain management research*. Supply Chain Management, 2(1), 15-22.
[15] M. Panchmatia. *Use Big Data to Help Procurement' Make a Real Difference*. 2015 Jin Y, Ji S. Partner choice of supply chain based on 3d printing and big data. Information Technology Journal. 2013; 12(22):6822
[16] GL. Schlegel. *Utilizing big data and predictive analytics to manage supply chain risk*. The Journal of Business Forecasting. 2014; 33(4):11
[17] GC. Souza. *Supply chain analytics*. Business Horizons. 2014;57(5):595-605
[18] NP. Suh, *Axiomatic Design: Advances and Applications*. New York: Oxford university press; 2001
[19] P. Trkman, K. McCormack, MP. De Oliveira, MB. Ladeira. *The impact of business analytics on supply chain performance*. Decision Support Systems. 2010;49(3):318-327
[20] MA. Waller, and S.E. Fawcett, (2013a), *Data science, predictive analytics, and big data: a revolution that will transform supply chain design and management*, Journal of Business Logistics, Vol. 34 No. 2, pp. 77-84.
[21] MA. Waller and SE. Fawcett (2013b*), Click here for a data scientist: big data, predictive analytics, and theory development in the era of a maker movement supply chain, Journal of Business Logistics, Vol. 34 No. 4, pp. 249 – 252.*
[22] G. Wang, A. Gunasekaran, EW. Ngai, T. Papadopoulos. *Big data analytics in logistics and supply chain management: Certain investigations for research and applications*. International Journal of Production Economics. 2016; 176:98-110

Elena PUICA, student at Economic Informatics Doctoral School, The Bucharest University of Economic Studies since 2020, working as a professional SAP Consultant.