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Enhancing Decision-Making In SCM: Investigating The Status-Quo And Obstacles Of Advanced Analytics In Austrian Companies

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Abstract

Over the past few years, the stability and predictability of logistics and supply chain networks have significantly decreased. This has led to higher risks and increased uncertainty in decision-making within supply chain management (SCM). Fortunately, the abundance of available data presents a tremendous opportunity to alleviate this uncertainty. However, realizing the full potential of advanced analytics, such as predictive and prescriptive analytics, is hindered by a lack of knowledge regarding their practical applications and performance benefits, as well as a deficiency in implementation expertise. This research paper examines the current state of advanced analytics applications and the primary challenges faced by Austrian companies in this domain. The findings reveal a distinct pattern: although the literature highlights numerous performance advantages, the practical utilization of advanced analytics remains at a rudimentary stage and is primarily confined to isolated departments. While demand management, procurement, and transport planning have shown some initial success in their implementation, other areas like production planning and, particularly, warehouse management lag. The primary challenges observed in practice include a limited understanding of the potential of advanced analytics, lack of transparency and data quality issues, difficulties in internal marketing, and inadequate organizational integration. These challenges, along with potential courses of action, serve as a starting point for other companies aiming to address similar issues. The significance of this work lies not only in its theoretical contribution to existing research on advanced analytics in SCM but also as one of the few studies that delve into the practical implementation and specific application domains of advanced analytics in Austria.

Keywords

Supply Chain Management; Advanced Analytics; Data Analytics; Logistics Networks; Decision Support.

1. Introduction

Over the past few years, the stability and predictability of logistics and supply chain (SC) networks have significantly decreased. This has led to higher risks and increased uncertainty in decision-making within supply chain management (SCM) [1]. At the same time, new technologies, such as advanced analytics, offer pivotal approaches for enhancing decision-making processes, optimizing operations, and ultimately improving the overall performance of supply chains [2]. Advanced analytics in SCM involves the use of sophisticated algorithms and models to extract valuable insights from large volumes of data, enabling companies to anticipate future developments, identify potential risks, and make corresponding decisions [3]. This is particularly crucial in today's volatile and competitive business environment, where the ability to quickly adapt to changes and make informed decisions can significantly impact a company's success.

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Fortunately, the abundance of available data presents a tremendous opportunity to alleviate this uncertainty. However, realizing the full potential of advanced analytics, such as predictive and prescriptive analytics, is hindered by a lack of knowledge regarding their practical applications and performance benefits, as well as a deficiency in implementation expertise [4]. Especially for smaller companies like SMEs or for smaller countries with limited labor force, the implementation of advanced analytics represents a significant challenge. In the case of Austria, a country characterized by a strong presence of small and medium-sized enterprises (SMEs), the application of advanced analytics in SCM is still in its early stages. Despite the recognized potential of these technologies, their actual implementation remains limited, and research in this area is often confined to analyzing theoretical potentials [6,5,4]. This presents a significant research gap, as understanding the specific challenges and opportunities associated with the implementation of advanced analytics in SCM in the Austrian context can provide valuable insights for both practitioners and researchers and can be transferred to comparably small countries. Hence, this paper aims to explore the application of advanced analytics in SCM in Austria, focusing on current implementations and the challenges associated with them. By doing so, it seeks to contribute to the existing body of knowledge and provide practical recommendations for companies seeking to leverage advanced analytics in their SCM processes.

Considering the above, this study poses the following research questions:

- RQ1: What are the current implementations of advanced analytics in SCM in Austria?
- RQ2: What challenges hinder the implementation of advanced analytics in SCM in Austria?

The answers to these questions will not only provide a snapshot of the current state of advanced analytics in SCM in Austria but also identify the barriers that need to be addressed to further its adoption. This, in turn, can guide future research and practice in this area, contributing to the advancement of SCM in Austria and beyond. The remainder of the paper is structured as follows: section 2 introduces the theoretical background of the study. Section three discusses the research methodology applied. In section 4 the results of the study are presented. Subsequently, section 5 concludes the paper, also providing limitations and outlook.

2. Background

Subsequently, the two concepts underlying the paper, i.e., SCM and Advanced Analytics (AA) are explained.

2.1 Supply Chain Management

A supply chain is a network of companies that work together to create and deliver a good (product) and its information (e.g., price, delivery window) to an end customer. A SC thus covers all companies involved in the value creation in the context of product creation and service provision and includes the totality of all activities and processes that are applied to a good from the beginning to completion and provision. In concrete terms, an SC begins with the producer of a raw material and ends with the provision or delivery of a product to the end customer. SCM - as defined by Mentzer et al. (2001) - is the "*systematic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole*." [7], p. 1.

The goal of SCM is to meet customer needs as efficiently as possible. This requires the optimization of numerous processes within and outside the company that are involved in the creation of value. Along with the development of the term SCM, the understanding of the tasks and activities in SCM has also changed. In the 1990s, the focus was still very much on the optimization and functional integration of internal supply chains. This purely internal view expanded in the 2000s to include the components of increased information exchange and collaborative management of complex value creation processes. Increasingly, the synchronization of internal and external supply chains also became a central goal of SCM [8]. Accordingly, there are many studies that deal with the specific tasks and processes in SCM. Lambert et al. [9] speak of

eight key activities in SCM, Chopra and Meindl [10] summarize 15 activities in three central SC macro-processes, the well-known SCOR model defines six core processes and numerous sub-processes in SCM [11] and Porter's value chain [12] names six primary activities. From the perspective of the present work, a categorization is selected that serves as a solid framework in the context of data analytics in SCM and can be used as a basis for the expert interviews. For this reason, we build on the work of Nguyen et al. (2018), in which fields of application and potentials at the interface between data analytics and SCM were elaborated. Thus, SCM in this paper comprises the following main activities [14,13]: i) procurement, ii) production planning, iii) warehouse management, iv) logistics and transport planning, and v) demand management.

2.2 Advanced Analytics

The term "Advanced Analytics" (AA) covers various aspects of the four categories of data analytics, i.e., descriptive, diagnostic, predictive and prescriptive analytics. In the following table, exemplary definitions from the literature are given and the term is delimited from the perspective of the work:

Table 1: Exemplary definitions of the term advanced analytics in the literature

Source	Definition
[15], p. 1388	*"Advanced Data Analytics is […] examination of data […] using sophisticated techniques […] to discover […] insights, make predictions or generate recommendations."*
[16], p. 12	*"Compared with conventional statistical methods, advanced machine learning algorithms are more capable of capturing complicated nonlinear relationships."*
[17], p. 1	*„Advanced analytics is a mixture of machine learning, artificial intelligence, graphs, text mining, data mining, semantic analysis. […] Beyond the traditional business intelligence, it is a semi and autonomous analysis of data by using different techniques and tools."*
[18], p. 266	*"ADA refers to the information systems and analytics applications used to collect, analyze, and extract insights from data to be used in organizational decision making."*
[19], p. 249	*"We started to use advanced data analytics (ADA) to describe the paradigm shift (i.e., from statistical hypothesis testing to automatically gathered data)."*
[20], p. 2	*"[…] advanced data analytics (ADA), as all the technologies that are part of it are related to the processing and analysis of data that goes beyond traditional […] procedures."*

In summary, and in contrast to conventional analyses and approaches of traditional business intelligence, which are limited to describing and summarizing data, advanced analytics uses advanced technologies and algorithms of machine learning and deep learning to recognize patterns in data, make predictions and provide recommendations for action as a basis for decision-making. Advanced analytics thus clearly focuses on predictive and prescriptive analysis, but also includes the identification of complex patterns in past data in the sense of descriptive and diagnostic analysis. Advanced Analytics hence primarily refers to models from the field of machine learning and deep learning. There are numerous works in the literature that deal with the categorization of machine learning models. Many roughly divide them into the areas of regression analyses, classification analyses and cluster analyses [23,22,21]. In addition, the categories of association and time series analyses, anomaly detection and reinforcement learning are frequently mentioned [25,24].

3. Research Methodology

The address the defined research questions, qualitative expert interviews are used as a suitable method. The aim of the expert interviews is to ascertain the current use and challenges in the context of advanced data analytics in Austrian SCM practices. Specifically, the aim is to identify i) how and in which SCM activities advanced analytics is already used in corporate practice and ii) where challenges lie in their implementation,

Expert interviews are particularly suitable if the aim of the survey is to analyze tacit knowledge in a defined knowledge field and among corresponding knowledge holders [28,27,26]. This is clearly the case in the present work. Expert interviews consist of the following essential steps: 1) identification and selection of experts, 2) data collection and 3) data analysis. In the context of expert identification and selection, an information-based selection approach is followed in the work. Based on defined characteristics, experts are identified and selected to participate in the survey [30,29]. Specifically, the selection criteria include: i) several years of experience in SCM in practice (> 5 years), ii) current involvement or leadership in SCM analysis tasks, and iii) overall management-level understanding of the use of advanced analytics in the respective SCM area through several years of experience (> 3 years) in the company. The search for suitable candidates was based on contacts at the Logistikum at the Upper Austrian University of Applied Sciences. The Logistikum is the largest research institution in the field of logistics and SCM in Austria and accordingly a broad network of corporate partners could be accessed (cf. www.logistikum.at). A total of 9 experts were interviewed, all from large companies. The details were anonymized at the request of the experts:

Table 2: Overview of expert participants

ID	Company / Industry	Expert status
1	Building industry	SCM process designer analyst; 8 years experience.
2	Automotive industry	Logistics and SC manager; 10 years experience.
3	Manufacturing industry	Head of Demand Chain for several years; 11 years experience.
4	Metal industry	Head of Data Analytics; 6 years experience.
5	Mechanical engineering	Head of Global Operations Excellence; several years experience.
6	Food retail company	Head of SCM Monitoring & Analytics; 10 years experience.
7	Mechanical engineering	Head of SCM with focus on production logistics; 10 years experience.
8	Paper industry	Purchasing manager, including all SCM tasks; several years experience.
9	Manufacturing industry	Manager in SCM Operations & Performance, 13 years experience.

Data collection is based on a semi-structured interview guide, allowing for a natural setting of the interview and at the same time ensuring that consistent questions in each interview - albeit possibly in a different order [31]. The interview guide was sent to the participants by email at least one week before the interview. The interviews were conducted face-to-face or by video conference via MS Teams. Each interview was recorded and analysed directly after the interview by analyzing recordings [33,32,34].

4. Results

Subsequently, the results of the paper are presented, focusing on current applications of advanced analytics in Austrian SCM practice (4.1) and the challenges occurring during their implementation (4.2.).

4.1 Current Applications of Advanced Analytics in SCM

4.1.1 Current Applications in Procurement

According to experts, advanced analytics is already finding first applications in procurement. In more than half of the companies surveyed, corresponding approaches are already being used successfully. Specifically, this includes the prediction of material requirements based on regression and time series analyses, building on parts lists (or also for checking parts lists) and decision trees, building on past orders. The optimization

of central order variables such as order quantities, times and the prediction of material prices is also a component of current applications of advanced analytics in procurement. Another use case is the analysis and prediction of supplier default risks based on pattern recognition and predictive analysis. In two of these companies, advanced analytics is not used independently, but in the form of AI-based standard solutions that include numerous optimization heuristics or machine learning models. The way this software functions is a black box for the respective company. The other half of the companies surveyed do not use any advanced analytics methods in procurement - apart from the use of classic ERP and MRP systems. However, all in all, from a practical point of view, there is still high potential in this area, which is not yet being exploited.

4.1.2 Current Application in Production Planning

The experts interviewed only apply advanced analytics to a small degree in production planning. The examples given include the implementation of image recognition to identify production errors or the use of regression and correlation analyses to identify unusually long machine downtimes and set-up times. One company uses optimization methods for production planning but relies on a purchased standard tool and does not know the details of the algorithms. In one company, initial trials have been carried out regarding predictive maintenance of production machines, but operational and actual use has not yet taken place. In the other companies, production is either planned manually based on parts lists and adjusted in the medium or short term, is rule-based, or plays no role (because it is a trading company).

4.1.3 Current Applications in Warehouse Management

The current use of advanced analytics in warehouse management is also limited in practice. Only one company uses such methods to derive central warehouse parameters (i.e., safety stocks and order points) and to identify inventory drivers. The company's goal is to predictively identify out-of-stock situations and subsequently avoid them while still maintaining efficient inventory management. In the other companies, inventory management is in conflict between production planning, procurement and demand management and is not dealt with separately in the form of advanced data analysis. Specifically, inventory management is usually driven by procurement, which in turn is driven by production, which is driven by predicted customer demand. A company flexibly rents warehouses or storage space from suppliers to deal with uncertainty in procurement. However, in terms of efficient inventory management, this is not really a sensible SCM tactic. Thus, warehouse management has not yet really been dealt with in Austrian practice.

4.1.4 Current Applications in Logistics and Transportation Planning

In logistics and transport planning - as in procurement - there are already first applications of advanced analytics in practice. At two companies, these include the optimizations of transport routes and the use of resources in this area through optimization processes. One company uses machine learning in the context of geospatial analyses to determine the optimal positioning of transport and distribution infrastructure, such as distribution centers and cross-docking stations. The same company also analyses patterns from past transport data in terms of determining optimal transport lot sizes and derives the future resource-optimal quantities accordingly. A fourth company uses artificial neural networks and regression analyses to predict and control future incoming and outgoing goods transports in the distribution center - here there is a direct connection to warehouse management. Other companies mostly use classic, rule-based transport management systems, plan transport manually or leave the transport planning to a logistics service provider. Thus, there is still unused performance potential of advanced analytics in logistics and transport planning.

4.1.5 Current Applications in Demand Management

In practice, demand management is the SCM area most intensively supported by advanced analytics. The experts name numerous successful fields of application here. In six companies, these include the use of

regression models or AI-based software to predict future customer demand. One of these companies also uses advanced analytics to predict the probability of certain BOM combinations, another already uses Explainable AI (to assess feature relevance) to make forecasts more understandable. In one of the companies, the demand forecast can also be adapted by manipulating selected parameters (e.g., inflation rate, market data, etc.) in the form of what-if analyses. The same company also uses machine learning and deep learning to determine or predict the ideal discount for individual customers. According to order and customer data, the probabilities of order completion and the corresponding contribution margin are predicted here depending on discount levels. In addition to these six companies, a seventh company does not use advanced analytics methods in the actual demand forecast but does use image recognition with customers to identify future repair needs and to point this out to the customer in the sense of demand management.

4.1.6 Summary of Current Applications

In summary, first solid applications of advanced analytics in basically all areas of SCM can already be seen in corporate practice. In particular, demand management, the area most intensively supported by advanced data analysis, procurement, logistics and transport planning already have concrete applications in most companies. In the area of warehouse management, advanced analytics is currently used the least, which is also in line with the literature. Interestingly, this also applies to production planning, which is one of the most researched areas in the literature. The following chart shows the current advanced analytics applications in the respective SCM areas named by the experts (in brackets the number of mentions):

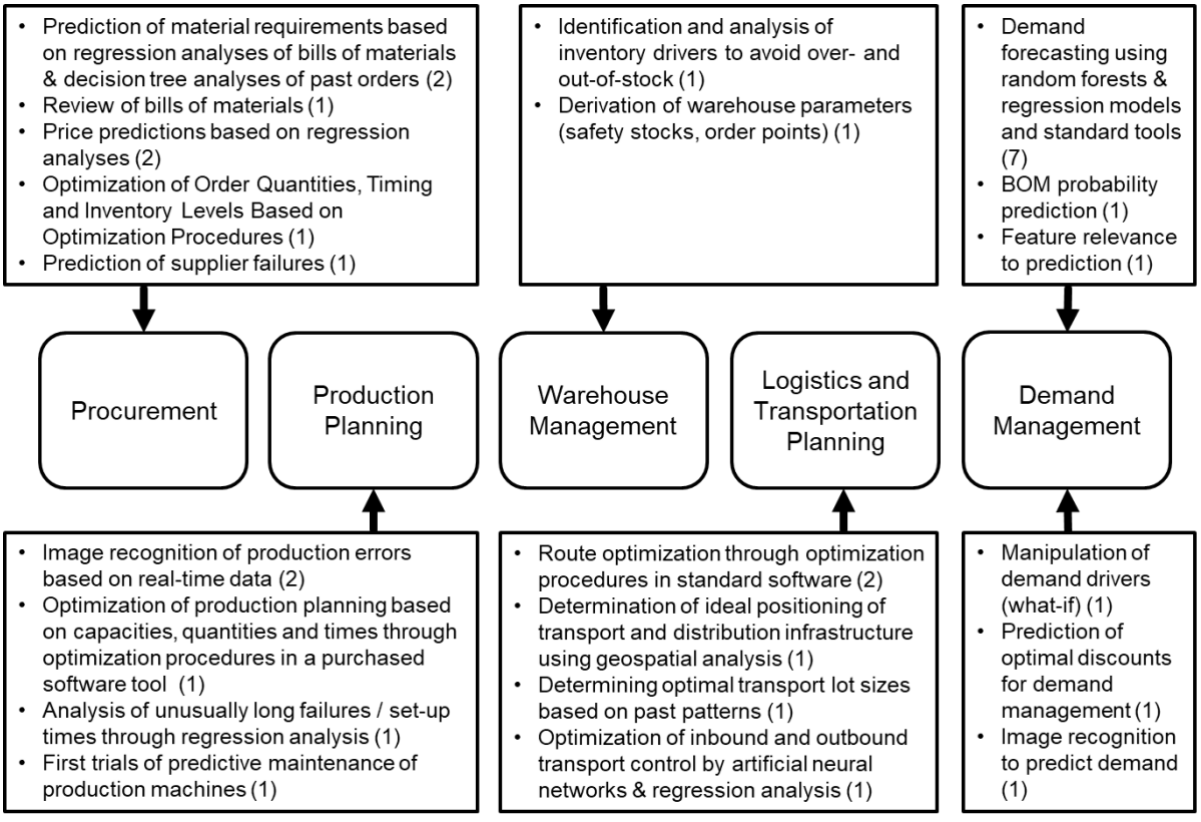

Figure 1: Summary of current Advanced Analytics applications in SCM

4.2 Challenges hindering the implementation of Advanced Analytics in Austrian Companies

From the experts' point of view, there are numerous challenges that need to be considered in the context of implementing advanced analytics in practice. Advanced analytics procedures are often perceived as black boxes. The results of such analyses are therefore difficult or impossible to comprehend and are viewed critically accordingly. If the results do not correspond to what is usually assumed or regarded as normal, acceptance among decision-makers in the company drops significantly as a result.

Another challenge is that the added value of complex analyses can often only be made visible and comprehensible afterwards, i.e., after their implementation. In practice, this means that investments in advanced analytics projects are often postponed, or such projects must be carried out without additional budget and with existing resources in addition to day-to-day business. The internal marketing of ideas or the creation of awareness in the company is therefore often laborious and it needs a strong and motivated driver with appropriate connections to management or - ideally - a direct supporter from top management. Often, successful applications fail because they are not sufficiently automated and integrated into operational systems. If a large amount of working time must be invested in the operational use of such solutions in order to carry out the analyses and use the results, the willingness to use them quickly decreases.

A lack of sufficiently qualified employees who can select, use and sustainably maintain complex models from the field of advanced analytics is also a challenge in practice. This goes hand in hand with the automation and integration of advanced analytics into company processes. If this does not take place, a high level of ongoing effort will be necessary in addition to the initial effort. From the point of view of SCM, the competence here usually lies in the market-side areas such as sales and marketing. Experts are therefore needed at the interface between data analytics and SCM who understand the use case and the technology.

Interface problems due to heterogeneous systems and infrastructure were also mentioned as major challenges in practice. Since isolated applications in individual areas do not enable the full potential of advanced analytics, many different systems must be integrated here, and their data processed or linked accordingly. This applies not only at the level of data extraction and preparation, but also in the context of result implementation in decision support. A directly resulting problem is that in some companies there is a lack of data understanding. There is transparency in one's own area, but across the board it is difficult to assess the data basis and draw conclusions about the data quality. There are also challenges at the level of the IT infrastructure. Infrastructures are still implemented locally for the most part, and cloud approaches are currently only used to a limited extent - both in terms of data storage and processing as well as analysis.

The organisational integration of advanced analytics is another challenge. In particular, the connection or distinction to classic reporting and the corresponding tasks must be well thought out in terms of acceptance. The same applies to the required roles and responsibilities. Here, the often still strongly anchored thinking in areas and silos or in operational and strategic activity profiles also represents a challenge that stands in the way of a cross-area SCM approach and optimization. A similar issue is that the scope or authority to engage in advanced analytics is often anchored in the parent company and little is possible nationally. This forces the emergence of central solutions that are as broadly applicable as possible, but which are often not applicable in specific local decision-making situations.

5. Conclusion, Limitations and Outlook

In this paper, a detailed analysis of the current application of advanced analytics in Austrian SCM practice and the challenges in this context has been conducted. The findings reveal a distinct pattern: although the literature highlights numerous performance advantages, the practical utilization of advanced analytics remains at a rudimentary stage and is primarily confined to isolated departments. While demand management, procurement, and transport planning have shown some initial success in their implementation, other areas like production planning and, particularly, warehouse management lag. The primary challenges observed in practice include a limited understanding of the potential of advanced analytics, lack of transparency and data quality issues, difficulties in internal marketing, and inadequate organizational integration. These challenges, along with potential courses of action, serve as a starting point for other companies aiming to address similar issues. Overall, advanced analytics is hence only applied to a limited degree, and there are several challenges that currently hinder further application.

From a practical point of view, the present work contributes to the identification of application and performance potentials of advanced analytics in SCM practice of small countries. The discussion of the implementation challenges enables other companies in similar settings to identify the central areas of action more quickly and to address them accordingly in terms of the recommendations for action derived. From a theoretical point of view, the work is one of the few studies that deals with the concrete design or the actual fields of application of advanced analytics in Austria. Possible limitations of this study are that only nine experts representing SCM practice were interviewed. In this context, however, the scientifically based procedure described in Chapter 4.1. for the selection of experts ensured that they were actual knowledge carriers from the SCM sector. The companies represented also come from numerous different sectors, so a very broad diversity of sectors was also considered. Nevertheless, the experts interviewed were only representatives from Austria, so a general picture of the use of advanced analytics in SCM at an international level cannot be provided. Building on the present work, similar surveys could be conducted in other countries and with a larger number of experts in future studies and their results discussed against the background of the current findings.

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Biography

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