

Artificial Intelligence's Level of Development and Influence on the Automotive Supply Chain in Europe: A Case Study on Audi

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ABSTRACT

Over the last few years, many factors have transformed the automotive supply chain in Europe. This paper addresses some of the issues that challenge this supply chain and discusses artificial intelligence's implementation benefits, such as the elimination of bottlenecks, gaining an advantage on the procure-to-pay system of the automotive supply chain, and the automatic read of invoices. Qualitative methodology was used to analyse the information gathered within this study, using in depth literature review and checking important releases on this subject in scientific papers available, focusing also on the Audi case study that shows real application of artificial intelligence technology into their manufacturing process and the opportunities to further apply this in Europe. Major changes in European automotive supply chains are underway as a result of the adoption of artificial intelligence, not only solves existing problems but calls for advanced algorithms to be developed to meet new demands. The implementation of artificial intelligence needs to follow ethics, and in some cases needs human supervision. The use of artificial intelligence has both advantages and disadvantages. Some are analysed in this article and the important role of Germany as a pioneer in using artificial intelligence effectively in the automobile industry is emphasized by a case study on Audi.

KEYWORDS: *Artificial intelligence, supply chain management, structural shift, automotive industry, Audi*

JEL CLASSIFICATION: *O31, L62.*

1. INTRODUCTION

Artificial intelligence (AI) has entered almost all spheres of life and is now coming to help improve the perimeter of supply chain management operations. This issue is critical in view of considering how AI will eventually influence the automotive industry, since AI can allow a complete redesign and reformulation of the processes involved in vehicle production for end consumers. AI allows for improving both performance and flexibility in automotive supply chains by applying machine learning algorithms together with predictive analytics. Since this paper focusses on the level of development, the consequences of AI in the European automotive supply chain will be carried out using two qualitative research methods: the document analysis method and the case study method. Some of the key inferences from the paper are that AI exists as a key driver of change in the automotive supply chain throughout Europe. Moreover, the case study on supports the fact that Germany is ahead in terms of using AI in the automobile industry.

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2. LITERATURE REVIEW

In Europe alone, most corporations are investing a huge amount of money into the research and development of AI technologies to just outdo their other competitors across the globe in such technologies. These currents of digitalisation and interconnectivity are a trend that constitutes rates much higher in comparison with most parts of the world because of technological advancement driven by research into AI. Thus, AI finds an application in automobile distribution, though with its challenges. It is to be noticed that some tasks performed by people, by going automated or mechanized, may lead them to lose their job.

Crockett (2023) emphasises that AI can benefit supply chains by increasing their efficiency and reducing the impact that could be generated by having only a small number of employees. Applications for AI are present throughout supply chains, from manufacturing all the way through consumer-facing retail (Tubaro & Casilli, 2019). Ahmed & Saideep (2023) believe that AI can automate manual supply chain tasks, which could drastically reduce time and costs. Tags that use Internet of Things technology are used to track inventory and promptly notify the supply chain companies about potential problems. The European Union (the EU) is trying to cope with green policies using digital transformation and attempting to build resilience within its member states to secure the current dependencies and the skilled workforce missing in the automotive sector. The most common challenges EU automotive producers are facing are linked to high dependencies on non-European suppliers, which lack both competencies in key development areas, but also cost competitiveness.

McKinsey & Company (2018) points out that AI is amazing at cutting costs and improving operations, while Landgrebe (2019) highlights the need for higher investments in smart algorithms to be able to keep up with the changes in the automotive industry.

Das (2022) discusses that the COVID-19 pandemic worsened issues such as labour shortages and increased demand for vehicles but managing supply chains with AI can help make operations more predictable, transparent and quick. Rusnak (2022) believes that adopting AI technology will improve key areas of the supply chain in the future, although he agrees with Das (2022) that the COVID-19 pandemic highlighted the weak points of supply chains.

3. RESEARCH METHODOLOGY

This article uses as research methodology the qualitative method of document analysis and the qualitative method of the case study. Most of the documents chosen to be analysed were published between 2021 and 2023.

The analysis is centred on how AI affects the automotive industry, with a focus on the automotive supply chain. The case study is about Audi, a German leading car manufacturer, which improved its operations by implementing AI. Some benefits of AI in the automotive supply chain include improved efficiency, reduced costs, and improved sustainability.

4. RESULTS AND DISCUSSIONS

4.1 The advantages and drawbacks of implementing artificial intelligence in supply chain management

As Negrea & Cojanu (2015) discuss, the balance between wages and industrial productivity is very important for competitiveness. If innovation and cooperation are not present, we might

witness some regions of the world that risk losing market portion and new business opportunities. Considering long-term strategic planning, research, development, and innovation become crucial, especially in high tech sectors like automotive. Since into the selling price wages and production hourly rates have a significant impact, to secure competitiveness, each region should maintain stable wage levels correlated with robust industry performance, inter-business collaboration, and a strategic focus on research activities. If this is not achieved, companies within the supply chain will look for cheaper options in low-cost countries to support their long-term project financial figures, moving business to more advantageous production locations.

Van der Smagt (2021) research brings following figures into study: automotive sector employs 14.6 million Europeans, thus proving to be a significant contributor to the EU job market. Additionally, the automotive industry is responsible for 11.5% of all manufacturing jobs in the EU, showing its importance and impact in the employment sector. Each year, 62 billion EUR are estimated to be spent on research and development within the automotive industry, which represents more than one third of the EU's total research and development spending.

Being an industry that carries significant amounts of technology, intellectual property, patents, innovation, and strategic planning, the automotive industry is the core of implementation from idea to product between the final customer, the personal or commercial vehicle, on- or off-road, and the car manufacturer.

It involves a complex supply chain, as the final product itself is the result of the cooperation of multiple industries for its assembly and delivery to market. Be it raw materials such as primary metals for building engine parts or complex chemical finishes for the hood, a large proportion is obtained through complex machining processes. All subcomponent producers need to manage their companies very well and cooperate to ensure that each project is completed qualitatively, on time.

Taking into consideration the many challenges that can appear in the automotive supply chain, professionals search constantly for methods to improve performance. As travelling became easier and markets were open to cooperation, a quality-to-cost orientation became noticeable, where typically a car is made from components coming from all over the world and can be assembled entirely or partially in completely different locations than the country of the car manufacturer. Financial services development and tax incentives brought a few countries to the attention of companies for headquarters settlement or research and development selection, including setting up plants in greenfield investment areas sustained by local governments that would enable the company to gain additional competitive advantages from price.

Jacobs (2023) enumerates the business advantages of artificial intelligence in the supply chain, referring to accurate inventory management, warehouse efficiency, enhanced safety, reduced operating costs, and on-time delivery.

By analysing daily challenges in the international automotive supply chain, we state and detail below our own original ideas for potential uses of AI to support critical activities and improve general output in automotive supply chain management in Europe.

Table 1. AI implementation areas and risks

Department	Activity	Value added	AI Risk
Quality	Validation accelerated tests	simulation results	data cyber security
Quality	Quality tracking Data matrix	improved traceability	data quality
Procurement	Procure-to-pay	order to invoice to payment	data confidentiality
Logistics	Warehousing and goods receipt	inventory management	data confidentiality
Purchasing	Supplier selection	auction platforms	data confidentiality
Finance	Pricing indexation	real time escalation/de-escalation	data cyber security
Logistics	Demand and stock management	on time stock	data cyber security

Source: Authors' creation (2024)

However, the list above has limitations: these areas of applicability can be considered, ensuring that the benefits overcome the associated risks and that the necessary budget for implementation is justified and can be made available by the company. Therefore, we detail in the following our view on each of the proposed areas of AI implementation.

Safety regulations in the European Union and globally, together with the manufacturer's experience and field results, make validation one of the most complex and extensive activities in the automotive industry. Certain categories of components that withstand high amounts of stress, wear, temperature, and pressure need to be tested and validated in terms of material, performance, and durability to ensure no field incidents or recall campaigns will occur due to their potential failure.

Data matrix implementation is an initiative through which AI helps to include in a quick response (QR) code all necessary agreed-upon information about the origin of the part, date of processing, number of operations executed, and other relevant information set internally in the company or agreed with the customer for it to be available for reading in their facility.

Many companies outsourced their functions of accounts payable and accounts receivable to countries that have low costs in order to ensure a better financial impact of these services. This can prove to be detrimental for the company, as any errors that could appear in this process could block payments to suppliers or from customers. Invoices posted late, wrongly categorised, accepted although they have missing information, or with major errors (that is, in the term of payment, account number, quantity, etc.) not addressed in time could even stop deliveries if the amounts are significant and if the parties' collaboration is at the beginning. The implementation of AI could also eliminate or reduce human errors. For instance, AI could automatically read invoices and post in an automated way, then send to payment. The risks associated with AI in this area of the supply chain come from cyber security.

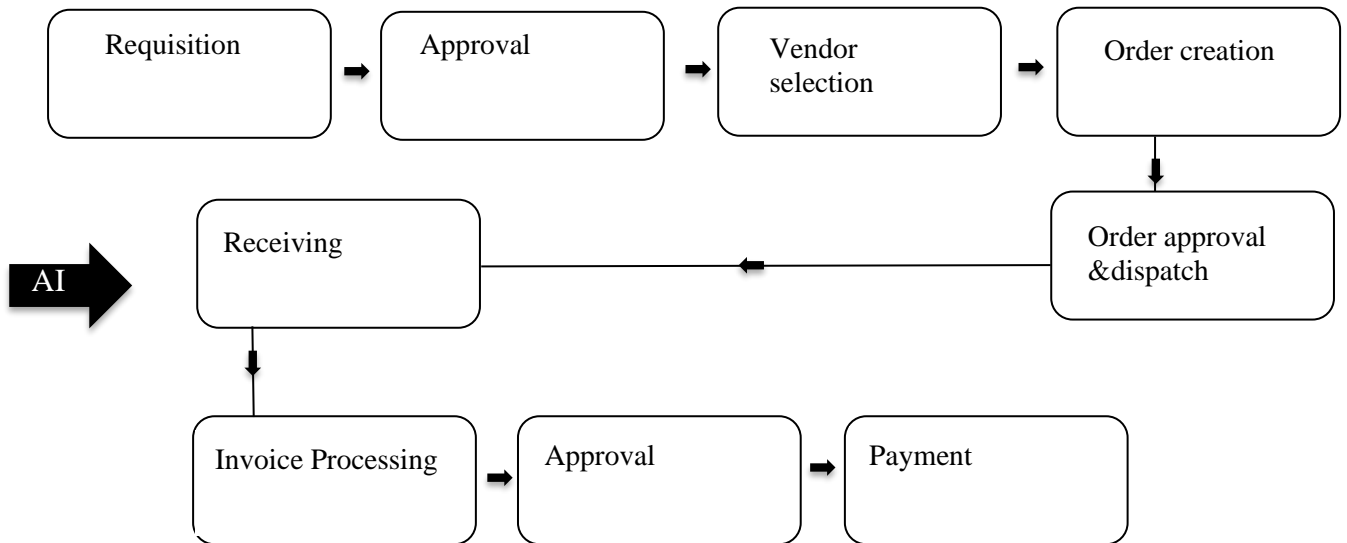


Figure 1. The Procure to Pay Process – Options to utilize AI

Source: Authors' creation (2024)

AI has both advantages and disadvantages in the context of cyber security. AI-based cyber security systems can improve the capabilities to detect and respond through identifying patterns of cyberattacks and threat intelligence.

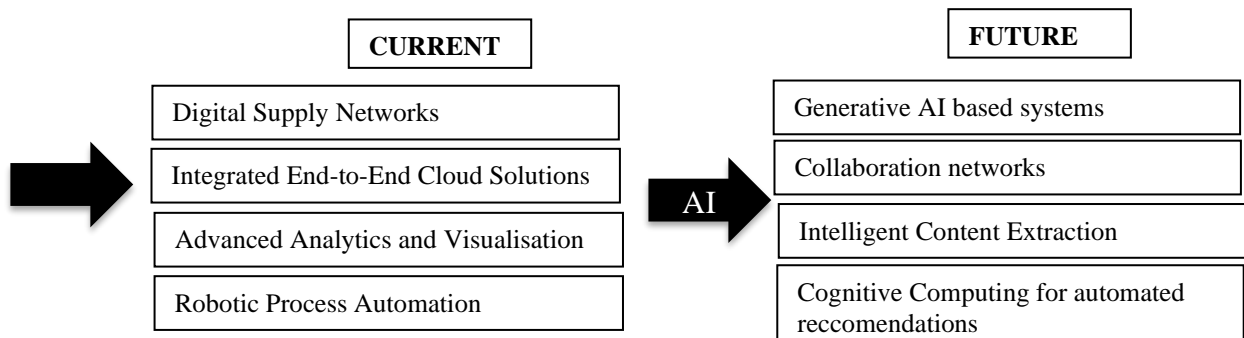


Figure 2. Transitioning from the Current to the Future Supply Chain by Implementing AI

Source: adapted from Deloitte (2023)

Choosing suppliers is critical in supply chains, because each product presents a set of benefits and risks in the relationship between supplier and client. When trying to decide for a supplier, customers usually compare the following variables: price, quality, on-time delivery, payment terms, the necessary investment, and the technical capabilities of the supplier. This decision is not always easy, which is why the implementing AI would dramatically improve the supplier selection process. The ideal process would start with the quotation phase where specifications would be automatically released to a pre-approved supplier panel, and it would continue with the supplier filling in the technical feasibility and quotation online.

As next steps, AI would select different types of data by interrogating fields and comparing them to both the budget allocated for the project and the internal assessment of costs. AI would then propose the suppliers target prices and would come forward with queries for improvement based on the analysis of costs.

Hamaguchi (2017) considers that AI can help significantly in repairing the risks associated with the transition to electric cars. AI is able to optimise charging schedules to be efficient and cost-effective by learning from daily habits and real-time electricity prices. AI could notify about issues and suggest measures to be taken as aftermarket services for electric vehicles. The European Commission (2023) highlights the policies that the EU has in place to mitigate the risks posed by AI.

Guibert (2021) mentions that the EU's initiatives having the scope to increase the competitiveness in Europe, and more specifically in the auto industry, allow Original Equipment Manufacturers (OEMs) to increase their profits as well as benefit from the societal advantages of AI. It is very important to balance the safeguarding of AI consumers with fostering innovation and market growth. When examining the risks mentioned above, the role of AI becomes more and more relevant, because it can pose risks, but also offer potential solutions. German automakers launched the Catena-X Automotive Network, which has the purpose of improving the digital supply chain through an open data network, and Fleherty (2021) discusses the implications of this initiative in his work. By combining collaborative data utilisation and AI, this network aims to improve supply security and promote digitalisation.

4.2 Case study: Audi's AI Implementation

Audi is a German automotive company part of the Volkswagen Group. It is very popular worldwide because of its automobiles. The fact that Audi buys materials and components from different countries places it in a worldwide supply chain network. This network entails stakeholders such as manufacturers, suppliers, and dealers spread globally. This global presence allows Audi to use better resources and to optimise the costs of production.

Audi's manufacturing system is very efficient, because components and materials are delivered to the manufacturing line just in time, according to certain deadlines, reducing inventory expenses. Moreover, Audi's seriousness made its relationship with suppliers very strong. This guarantees the high quality of Audi's vehicles, as well as Audi's reliability. The company also has in place principles in its activities connected to the supply chain that have the scope of eliminating waste and making operations more efficient.

The fact that Audi is responsible regarding the environment implies, among others, that it aims to reduce the emissions of carbon and it want to only use sustainable materials, while preserving the natural resources. Audi and the Volkswagen Group took measures to improve the resilience of their supply chain during the COVID-19 pandemic. Gupta et al. (2021) believe that algorithms based on AI can process data in real-time and offer options such as selecting personalised settings and features for safety. Audi checked the reliability of its AI-based software for more than 4,000 suppliers and concluded that AI is efficiency in responding quickly to supply chain risks (Supply chain monitoring: Audi uses artificial intelligence (AI) for sustainability, 2021).

AI also has an important role in the ecosystem that connects vehicles at Audi, in order for them to communicate and offer real-time traffic updates. Dumitraşcu et al. (2020) describe how AI was used to find links between issues found in supply chains and certain key performance indicators (KPIs). Williams et al. (2022) discuss the supply chain vulnerabilities related to AI. Audi's AI adoption improved its supply chain operations and prove Germany's development in this respect.

5. CONCLUSIONS

Although AI can improve the efficiency, resilience and sustainability of automotive supply chains, it must follow ethics and in some cases has to be accompanied by human supervision due to the risks associated with this technology. Moreover, companies that wish to implement AI successfully have to invest in both technological and human resources.

By using AI, Audi improved its operational efficiency and product quality and also set an example for being sustainable, resilient, and innovative in the automotive industry. This paper presents the opportunities to use AI in the automotive supply chain in Europe, bringing forward a case study of the car manufacturer Audi that is a true pioneer in this respect. The literature review shows how AI is able to mitigate high-impact supply chain risks while improving productivity and even creating a competitive advantage. The authors of this study gathered the hypotheses of recent and relevant studies available and compared them with the Audi case study and their own automotive supply chain experience to check and propose areas that would benefit most from AI implementation, while bringing the awareness that AI regulation is in its infancy and there may be risks associated with AI usage, such as cyber security, data quality, and privacy rights. Our study offers a broader perspective using the combined qualitative research methods of literature review and case study. There are additional conclusions and hypotheses that could be validated through quantitative research, a goal to be achieved by the authors in future work.

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