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Industrial Engineering and Management

Bachelor thesis proposal

**The role of explainable artificial intelligence (XAI) in decision-making for food supply chain management**

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# List of abbreviations

XAI Explainable artificial intelligence

FSC Food supply chain

FSCM Food supply chain management

SCORM supply chain operations risk management

GDPR General Data Protection Regulation

# Problem Description and analysis

Modernsupply chains have become increasingly dependent on efficient management and utilization of data and information as opposed to previous periods where asset management had been more crucial to the domain [1]. This shift towards more data-centric and information-driven systems was followed by most of the prominent technologies known today, such as IoT, cloud computing, and artificial intelligence [1]. However, as most of the industry, 4.0 paradigms have been restricted to positions of necessity, AI continues to emerge as a “competitive advantage”. This is demonstrated by multiple companies shifting from limiting the use of AI systems from remote monitoring activities to implementing control, optimization, and finally, advanced autonomous AI-based systems to improve their functionality [1].

One important domain where the application of new and emerging AI systems is yet to be fully discovered is the area of supply chain management in the food industry (FSC) [2]. This supply chain is composed of four key stages namely - production, processing, distribution, and retail [3]. Over the past years, the need for computational intelligence in the domain has increased rapidly, and this is mainly attributed to the massive amounts of data being produced in each of the respective stages mentioned above [3]. This is highly attributed to the rise of digitalization enabling technologies such as internet of things, that have been incorporated in fundamental processes in each of the stages mentioned above [3]. All in all, this has made food supply chains more efficient, responsive, and overall more sustainable [3].

There are different types of AI models that can implemented depending on the problem at hand. The following major computational intelligence problems have been identified in the four stages of Fsc - communication and perception, knowledge discovery and function approximation, uncertain knowledge and reasoning, and problem solving [3]. Each of the above mentioned categories implement wide range of AI models depending on the specific problem at hand [3]. Below is a taxonomy of major processes that can be addressed with the computational intelligence methods mentioned above in each stage of the FSC according to authors in [3].

Diagram

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(Fig. 1. *FSC problems in the production stage* s.d.) (Fig. 2. *FSC problems in the processing stage.* s.d.)

Diagram

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(Fig. 4. *FSC problems in the retail stage.* s.d.) Fig. 3. *FSC problems in the distribution stage.* s.d.)

There are various Fsc problems from the different stages that can be addressed by various types of computational intelligence/ artificial intelligence methods as seen in the categories above. However, a major underlying problem in each of the categories is the interpretability/ expandability of the AI models used [4]. Even though they are meant to assist supply chain operational risk management, they are all “black box” by nature [4].

The term “black box”, refers to the inability of the chosen method to comprehensively present why a certain outcome has been reached [4]. This means that the output presented cannot be examined for any biases [4]. To tackle this issue researchers are now proposing a shift to more explainable models when it comes to supply chain operations [4]. Explainable AI models or XAI models , are auditable, transparent and can be described as “white box AI systems”, as they not only present outputs but also the decision-making process leading to the outputs [5].

The fundamental aim of an XAI is to offer models with high accuracy, transparency, and exploitability [4]. Consequently, the major features of an XAI model are – trustworthiness, completeness, admissibility, transparency, and interpretability [4]. Below is more comprehensive view of the major scaling features of an XAI methodology according to authors in [4].

Diagram

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(Fig. 5. *Explainability in supply chain operational risk management: A systematic literature review* 2022)

## Theoretical relevance

AI systems don't take into account whether the human experts regard the classifiers or predictors used to determine an output as trustworthy or dependable [4]. This flaw prevents such procedures from being interpretable or comprehensive enough to explain the results they produce [4]. With XAI, experts can determine whether the computed output is impartial, dependable, and trustworthy [4]. The need for interpretation of computational outputs, particularly in domains such as FSCM, is primarily driven by in the lack of confidence in AI-recommended decisions, as erroneous resolutions might result in failures with significant effects [4].

## Practical relevance

This paper aims to identify the lack of explainability in the most popular models used in the food production segment of the FSCM process, and propose XAI models that can present transparent, interpretable, and trustworthy outputs.

# Aims of the thesis

## Descriptive aims

This thesis aims to explore the role of the new and emerging subclass of artificial intelligence XAI and its relevance for the field of supply chain management - specifically food supply chain management.

## Pragmatic aims

The research will start by analyzing the as-is situation by exploring and categorizing the various types of scenarios in the fundamental stages of supply chain management that have been known to implement AI. The second aim would be then to implement an XAI approach towards solving a particular problem related to the production stage in food supply chains, this will then help us understand the difference between regular AI models and XAI models.

## analytical aims

The research then aims to discover the scenarios where transparent and explainable AI models can be implemented to ensure human involvement and improve traditional processes in food supply chain management.

# Course of research

The research gap in this field is considerably large, as the field of XAI is relatively new.

The first method used in the research will be literature analysis. The first step was to drive a search string that can be used to identify articles which apply XAI for different stages of food supply chain management, weather in a specific niche or a general model. The search string would target the abstract of the articles and contains chosen phrases along with their derivatives. The final refined search string is as follows.

( ABS ( "food supply chain"  OR  "food supply network"  OR  "food supply system"  OR  "food production"  OR  "food distribution"  OR  "food retail"  OR  "food manufacturing"  OR  "agriculture"  OR  "farming"  OR  "crop management"  OR  "livestock management"  OR  "food distribution"  OR  "food"  OR  "farming"  OR  "crop management"  OR  "crop"  OR  "food inventory management"  OR  "food fulfillment"  OR  "food delivery"  OR  "crop yield"  OR  "food retail"  OR  "nutrition"  OR  "food safety"  OR  "food quality"  OR  "agriculture output"  OR  "agriculture" )  AND  ( "explainable artificial intelligence"  OR  "explainable AI"  OR  "interpretable machine learning"  OR  "interpretable AI"  OR  "transparent machine learning"  OR  "transparent AI"  OR  "white-box machine learning"  OR  "white-box AI" ) )

Chart, pie chart

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Fig 6. Own creation – articles by FSC stage

Additionally, the research will attempt to examine the as-is situation by employing text classification of multiple articles on the subject matter that can be obtained through Scopus. This classification will generate a taxonomy of the use of XAI in food supply chain management using rule-based classifications. Below is an overview of a taxonomy based on the use-case and model category implemented.

Chart, histogram

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Fig 6. Own creation – Models mentioned Fig 6. Own creation – articles by XAI use case

Secondly, the research attempts to employ a chosen XAI model on a chosen dataset that contains multiple features to predict crop yield Germany, in a manner that could be interpretable, and draw comparisons with traditional AI methodology.

# Outline

* Introduction (problem description, theoretical and practical relevance, aims)
* Background and motivation
* Literature review (XAI, food supply chain management, taxonomy of XAI in food supply chain management)
* Methodology (literature review, taxonomy preparation/text classification, XAI model implementation)
* Discussion (theoretical and practical relevance, limitations, implications for future research)
* Conclusion
* References
* Appendices

# Timetable (Gannt chart)

Graphical user interface, application

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# Relevant literature

R. Toorajipour, V. Sohrabpour, A. Nazarpour, P. Oghazi, and M. Fischl, ‘Artificial intelligence in supply chain management: A systematic literature review’, J. Bus. Res., vol. 122, pp. 502–517, Jan. 2021, doi: 10.1016/j.jbusres.2020.09.009.

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“What Does Transparent AI Mean?” *What Does Transparent AI Mean? – AI Policy Exchange*, 9 May 2020, aipolicyexchange.org/2020/05/09/what-does-transparent-ai-mean.

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[1] R. Toorajipour, V. Sohrabpour, A. Nazarpour, P. Oghazi, and M. Fischl, ‘Artificial intelligence in supply chain management: A systematic literature review’, *J. Bus. Res.*, vol. 122, pp. 502–517, Jan. 2021, doi: 10.1016/j.jbusres.2020.09.009.

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Figure 2. *FSC problems in the processing stage.* (s.d.) At: https://www.mdpi.com/1424-8220/21/20/6910

Figure 3. *FSC problems in the distribution stage.* (s.d.) At: https://www.mdpi.com/1424-8220/21/20/6910

Figure 4. *FSC problems in the retail stage.* (s.d.) At: https://www.mdpi.com/1424-8220/21/20/6910

Figure 5. Nimmy, S.F. *et al.* (2022) *Explainability in supply chain operational risk management: A systematic literature review*. *Explainability in supply chain operational risk management*.