A Framework for Artificial Intelligence Capabilities for Challenges in the Supply Chain for Business-to-Business Companies

Author: Ron Kassies
University of Twente
P.O. Box 217, 7500AE Enschede
The Netherlands

ABSTRACT,
Currently, the supply chain of business-to-business organizations is under intense pressure caused by a lot of external and internal influences. Possible solutions to solve this pressure is digitalization, for instance, with the implementation of artificial intelligence systems. Based on the research model of a systematic literature review, nine exploratory interviews were conducted to validate the criteria for making the supply chain of an organization AI-ready. The literature review showed the following themes with the focus on AI in the supply chain: opportunities and challenges, capabilities, practical implementations, and improvement of systems for performance. These themes are framed and can be seen as certain steps. The nine interviewed B2B organizations are from several industries divided into three size categories. The qualitative research addressed the relevance and flow of literary themes. This resulted in a framework that is useful for the approach of AI implementation in the supply chain of B2B companies. In addition, it raised the awareness and potential power of artificial intelligence to empower the internal supply chain.

Graduation Committee members:
First supervisor: Dr. A. Leszkiewiccz
Second supervisor: Dr. M. de Visser

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Artificial intelligence, supply chain, capabilities, business-to-business, AI readiness, AI implementation

1. INTRODUCTION

1.1 Motivation for the Topic

Organizations are always struggling to find the right short-term and long-term strategy. Strategies for organizations that lead to innovation activities and value creation are often likely to break down barriers in the industry they operate in. Most of the time there is enough data 'hidden' in the organization, which could support and lead to innovation, value creation, and solutions. Artificial intelligence is relevant and useful for finding solutions with data already being available in the organization. Hence, this could be implemented in the constantly more challenging supply chain management. The COVID-19 pandemic has raised the need for agility and flexibility in the supply chain.

1.2 Research Context

The awareness of the environmental impact of the supply chains has triggered the regionalization and optimization of flows. That is why companies and stakeholders are more focused on supply chain resilience. For instance, AI technologies such as automation, processing technologies, continuous-flow manufacturing, and additive manufacturing, are solutions for lowering costs, increasing flexibility, and being more environmentally sustainable. However, in what way can an organization adapt some sort of technology in the operations? Before actually using an AI solution, a firm needs to be ready for implementation and be ready for the actual use of AI. For the majority of companies, the steps are unclear, too difficult to manage, and incalculable. That is one of the reasons why it takes a lot of time before an organization ventures on the journey of supply chain AI optimization. The focus in terms of the supply chain is shown in Figure 1.[1]

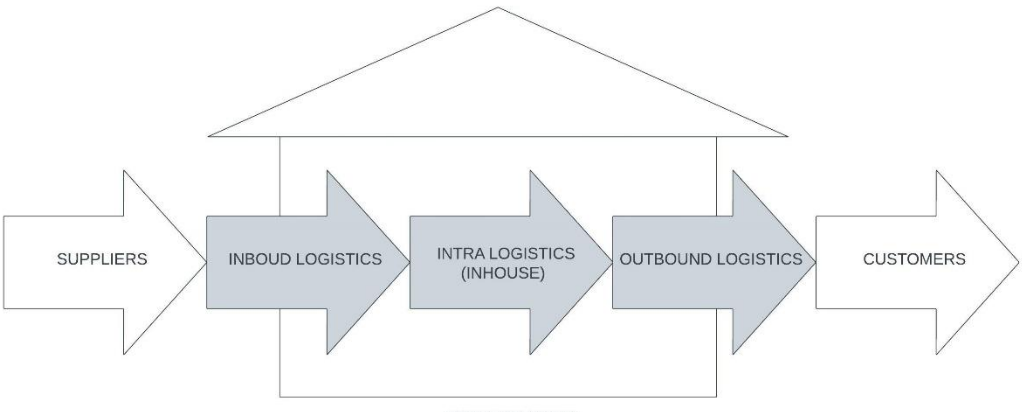

Figure 1 Supply chain outlined.

The COVID-19 pandemic has disrupted the complete supply chain, which is still leading to a scarcity in, for example, all kinds of commodities. In addition, the pandemic showed the relevance and essential

[1] https://www.logistiikanmaailma.fi/en/logistics/logistics-and-supply-chain/inbound-inhouse-and-outbound-logistics/

importance of supply chain management (Craighead et al., 2020). Research shows that supply chain analytics, e.g. artificial intelligence, supports the improvement of complex supply chain processes and decisions (Akter et al., 2020). The dynamic capability perspective and the environmental dynamics, e.g. in terms of alliance management, enhance the operational and financial performance of an organization (Dubey et al., 2021). Hypothetically, AI is the solution to the disruption of the supply chain.

1.3 Research Gap

The research can be seen as a sustainable business model, which addresses the possible AI innovations in the supply chain. Addressing certain factors in organizational design that affect dynamic capabilities, reframing or reforming those factors, and implementing them can be seen as an AI solution (Bocken & Geradts, 2020). In theory, there are two interconnected categories of capabilities: ordinary and dynamic. Ordinary capabilities are most of the time operational and dynamic capabilities are related to strategy (Teece, 2017). According to Teece (2017), dynamic capabilities can be divided into three clusters: sensing, seizing, and transforming. In addition, the dynamic capability approach supports the firm's assets, for instance, the collective knowledge and capabilities of the firm. These intangible assets are hard to imitate and scarce, it would be beneficial for an organization to maximize them. AI adoption and impact are according to McKinsey research, for example, satisfactory for significant cost decreasing and revenue increasing.[2] AI has great potential in the business field. There are already a lot of advanced business opportunities for the implementation of AI. It seems like the barriers of organizations are too large or complicated. Perhaps it is possible to make it less complex if companies have a certain framework to test if the organization is ready for the implementation of AI. The criteria in the framework will lead to a well-defined AI supply chain opportunity based on the organizational dynamic capabilities. The goal is that every organization that is willing to develop its supply chain will benefit from the research.

1.4 Research Problem

Organizations that add value to the products in their supply chain have an enormous benefit when they make certain processes autonomous. However, most of the time this regards individual processes in the supply chain. Currently, it is very hard to integrate and automate all the processes of the supply chain. The problem, in this case, is that human beings are still directly involved in the decision-making

[2] https://www.mckinsey.com/business-functions/quantumblack/our-insights/global-survey-the-state-of-ai-in-2021

process and have to make the interdependencies among the individual applications. AI and machine learning have the potential to significantly improve the supply chain performance of any organization.

1.5 Research Questions

In sum, many organizations are facing huge challenges in innovating the supply chain system. The best solution is to optimize and implement AI technologies, which will solve many challenges and support the organization. The research will hypothetically create a framework for AI implementation. It allows firms to assess AI capabilities for making the organization more AI-ready. Therefore, the following research question is made:

To what extent can AI capabilities lead to a successful AI implementation in the supply chain of a business-to-business organization?

Based on four sub-questions, the main research question will be answered.

1. *What kind of dimensions or capabilities need to be addressed or are available in an organization when AI is implemented?*
2. *What are the organizations' priorities that are willing to implement AI in their organization?*
3. *What is the impact of AI capabilities on supply chain performance?*
4. *What is the short-term and long-term need for business-to-business companies according to AI solutions in the supply chain?*

2. STATE OF AI IN COOPERATION

2.1 Organizational AI Readiness

First of all, it is important to clarify the definition of AI readiness for organizations. To mention the AI readiness criteria, this research takes the definition of an organization's ability to deploy and use AI in ways that add value to the organization (Holmström, 2021). In addition, AI readiness factors are defined in the following dimension: strategic alignment, resources, knowledge, culture, and data (Jöhnk et al., 2021).

2.2 AI Capability

An AI capability is the ability of a firm to select, orchestrate, and leverage its AI-specific resources (Mikalef & Gupta, 2021). When comparing the readiness with the capability definition, the capability perspective can be seen as the next step in AI implementation. Furthermore, the following AI capability dimensions will be researched: AI literacy, AI technology alignment, AI business eco-system, AI organizational practice, and AI ethicality. These dimensions are described and can be seen in Table A.1 of Appendix A.

2.3 AI Adoption

The AI adoption phase can be divided into three phases, which can be seen in Figure 2. Firstly the initiation phase, where organizations recognize the needs, become aware and create a potential proposal for the adoption of AI. In this way, AI is seen as a certain innovation. The second phase consists of an evaluation of the potential innovation that will take place as the acceptance or rejection of implementation. Finally, the implementation stage which covers the acquisition and the continued use (Jöhnk et al., 2021).

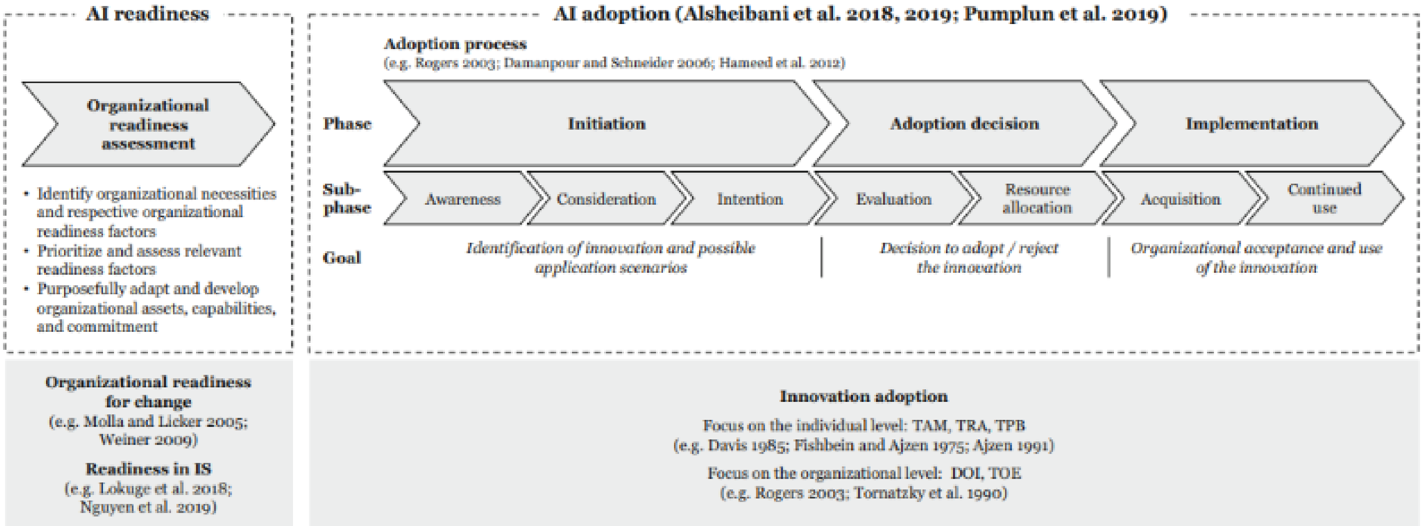

Figure 2 AI adoption process phase (Jöhnk et al., 2021).

3. AI IN SUPPLY CHAIN MANAGEMENT

For the analyses, the Gioia method is used (Gioia et al., 2012). This approach is used to find the first-order concepts, which contain key sentences and quotes in the articles. The next step, the second-order theme, is to find the main themes in the articles. When the selection of the quotes is correct, the theme is already present in the quote. This theme needs to be compiled in the leading emerging aggregate dimensions. This is all present in Table B.3 of Appendix B. The following themes are the established aggregated dimensions:

- Supply chain AI opportunities and challenges
- Capabilities of AI supply chain improvement
- Practical AI supply chain implementation
- Improvement system for supply chain performance
- Supply chain AI strategy management

All these dimensions are related to the research. In the next section, the main findings of the found theoretical aggregated dimensions are discussed.

3.1 Supply Chain AI Opportunities and Challenges

Many opportunities and challenges are correlated. Overcoming a challenge most likely opens up opportunities for organizations, which explains the correlations. That is why the theoretical constructs are intertwined. For instance, the TOE framework with the constructs of technology, organization, environment, and perceived benefits for AI adoption (Mahroof, 2019). This theoretical framework explains how technology adoption and implementation are influenced by the contexts of the described constructs. Focusing on these dimensions results in, for example, higher operation efficiency, higher service levels, and lower operating costs (Chung, 2021). Taking into account the parameters or in other words (cultural) challenges, such as diversity, equity, ethics, privacy, data protection, misuse protection, audit and transparency, digital divide, and data deficit. For this reason that an objective view of the desirability and the safety of the AI solution is crucial in later implementation. In other research, it is more common to skip the focus on challenges and keep only attention on the practical contributions more in line with Industry 4.0 (Azadi et al., 2019; Meindl et al., 2021). To put it simply, the focus in papers is most of the time only on the opportunities instead of starting with challenges.

3.2 Capabilities of AI Supply Chain Improvement

According to AI supply chain improvement, many capabilities are correlated in papers or articles. Entrepreneurial orientation and a dynamic capability view are two basic capabilities (Dubey et al., 2020) that must be present in an organization for AI improvement. These capabilities encounter the principles, for instance, responsiveness (Medvedeva et al., 2020), supply chain resilience, provenance, reengineering, enhancement, (process) management (Dutta et al., 2020), supplier relationship (Portna et al., 2021), agent-based systems (Xu et al., 2021) and operating excellence (Mangla et al., 2020). When these elements of capabilities are available and improved it is easier to achieve, efficiency and sustainability in the elements (F. Zhang et al., 2020).

3.3 Practical AI Supply Chain Implementation

Decision support systems based on the capabilities and opportunities and challenges of an organization are practicalities that are relevant for possible implementation (Kamble et al. 2021; Koot, Mes, and Iacob 2021). Data velocity, volume, and variety are basics that must be well organized before AI implementation (Silva et al. 2021; Naeem et al. 2020). In addition, the architecture of logistics management, production scheduling (Liang, 2020), communication architecture, and data preparation (Coito et al., 2020) must be settled before optimizations can be achieved. Optimizations for price strategy (Benhamida et al., 2021), warehousing, business intelligence (Naeem et al., 2020), demand forecasting (Seyedan & Mafakheri, 2020), production logistics management, and production scheduling (Liang, 2020) can all be accomplished when the basic foundations are appropriate. The most essential terms besides the basics of data velocity, volume, and variety are data quality and data documentation (Silva et al., 2021). According to Silva et al. (2021), improvement of data documentation will cause a decrease in time and effort needed for future projects. Detection and reporting of problems are related to data quality, maintaining a high level and improving the data quality constantly is essential.

3.4 Improvement of System for Supply Chain Performance

Good improvement of systems, e.g. AI solutions, are based on the attributes of reliability, responsiveness, agility, assets, and costs (Lima-Junior & Carpinetti, 2020). These attributes are key to successful supply chain performance; the proposed system allows managers to evaluate their strategy and contributes to the proactiveness of improved performance according to Lima-Junior and Carpinetti (2020). Pricing based on assortment planning, shelf space allocation, and inventory planning can be significantly improved by meta attributes, which will increase the supply chain performance of an organization (Sajadi & Ahmadi, 2022).

3.5 Supply Chain AI Strategy Management

Practically all organizations desire an optimal supply chain strategy. Recognizing the capabilities of data applications such as demand, market values, and weather fluctuations can result in reliable AI results that are appropriate sources for strategy management (Chandrasekaran et al., 2021). In addition, the digitalization of intern supply chain processes will benefit performance (Dev et al., 2019; Rahimi et al., 2020). Trying to conceptualize the architecture of supply chain 4.0 must be the goal of every organization with a supply chain aiming for a sustainable, successful, and long-term way of operating (Sobb et al., 2020).

4. RESEARCH DESIGN FOR COMPOSED FRAMEWORK

The research design is divided into two sections. Firstly, a systematic literature review based on the phases of identification, screening, and eligibility is excluded. For detailed information regarding the systematic literature review, see Appendix B. Hence, the main result of the literature research is the aggregated dimension themes in the theory section. Secondly, interviews with a target group are used to validate the framework. The interviews are based on the qualitative semi-structured interview guide, as it increases the trustworthiness and objectivity of the results. (Kallio et al., 2016). Besides, the interviews can be seen as a validation of the framework in terms of relevance.

This thesis aims to create a framework that assesses the capabilities of organizations for AI implementation based on previous literature. The focus will be on the supply/logistics segment of the organization. By first looking at the existing, accessible, and possible AI capabilities, the research will lead to useful insights and improvements. The purpose of the framework is to assess all the AI-opportunities and challenges, capabilities, practical implementations and improvements systems for performance that are present or in potential can make available in the organization.

4.1 Qualitative Semi-Structured Interviews

The five-step process to develop the semi-structured interviews were taken into account while creating the questions based on the framework. Nevertheless, due to trustworthiness, the approach can be redefined into three steps: credibility, confirmability, and dependability (Kallio et al., 2016). The credibility step regards knowledge and theory based on the literature review. Formulation of the preliminary interview guide, i.e. confirmability step is executed based on the theory and revised by using an academic and industry perspective of experts/advisors. The dependability step is accomplished by actively performing interviews with the target group.

The participating companies were selected based on certain criteria. In the first stance, the organizations have to operate in the business-to-business context. Even as they need to have intern and extern supply chain processes. In addition, the company has to add value to the incoming resources before they sell the product to their customer. Lastly, companies categorized into three groups are interviewed. These categories are micro-, medium- and large-sized companies, according to the definition of the European Commission in Table 1.[3] The focus in classifying the companies is on staff headcount, as activities and the adaption of new technologies of an organization are mainly caused by employees (Forman, 2005). Moreover, the category of small companies, e.g. <50 employees, is not taken into account because research suggests that the differences between micro and small organizations are negligible (Pearson et al., 2006). In addition, the interviewees were entrepreneurs, supply chain engineers, logistics managers, and purchasing managers from various branches. The

COMPANY CATEGORY	STAFF HEADCOUNT	BRANCHE	
1. Micro	< 10	1.1	Information and Technology
		1.2	Agricultural sector
		1.3	Promotional gifts industry
2. Medium	< 250	2.1	Plastic manufacturing industry
		2.2	Information and Technology
		2.3	Wholesale trade
3. Large	≥ 250	3.1	Steel related industry
		3.2	Tire industry
		3.3	Information and Technology

Table 1 The three categories of the size of enterprises.

[3] https://ec-europa-eu.ezproxy2.utwente.nl/growth/smes/sme-definition_nl

numbers in front of the branches express the company category, e.g. 3 is large, and the industry, e.g. 3.2 is the tire industry of a large-sized organization. These numbers are also used in the table of the processing of the interview results in section 5.

AI definition concerns the innovation in the processes of an organization's supply chain e.g. optimizing warehousing. The creation of awareness of AI opportunities can be seen as a goal of the interviews as well. In addition, for testing the interests in the proposed framework in the thesis, a questionnaire is added based on the validation of entrepreneurial orientation and dynamic capability view (Dubey et al., 2020). The interview questions can be found in Appendix C. By contacting different organizations in the business-to-business fields, interviews and possible company visits were arranged. The objective was to create a new, successful, and innovative AI supply optimization framework based on supply chain data capabilities, which results in opportunities and advice for organizations. In other words, new innovative insights for facing problems in the supply chain from an external perspective. The framework is created to ensure that organizations have a support tool for making an effective and efficient innovative supply chain including AI.

4.2 Data Analysis

The data analysis can be approached from two perspectives, based on the combination of the two methodologies The first perspective is the processing of the processed literature resulting from the literature review. It is framed in a certain framework, which is validated through qualitative interviews, i.e. the second perspective. Each interview is analyzed on a stand-alone entity that allows for finding unique patterns (Eisenhardt, 1989). The nine interviews are handled in Table 2 of section 5, to show theory-based and organization size-based patterns. According to Eisenhardt (1989), the method gives researchers familiarity with each particular case. Generalizing the validation results from the interviews is done in section 5. Whereas the final framework is shown at the end stage of the report.

5. INTERTWINED RESEARCH RESULTS

5.1 Framework for AI Adoption in the Supply Chain

In the systematic literature review, the following themes relating to AI and the supply chain emerged: opportunities and challenges, capabilities, practical implementation, improvement system for performance, and strategy management. These themes can be considered in a certain step approach, that can be shown in a certain framework. The themes of opportunities and challenges and capabilities are the first step. The opportunities and challenges for the organization have been adopted, based on the challenges, the results can be higher in operation efficiency, service levels, and lower operating costs. The next literature theme focuses on the 'macro-capabilities' of the firm, such as entrepreneurial orientation and dynamic capability view. Nevertheless, specific elements, e.g. supply chain resilience and responsiveness, are required to achieve the results of efficiency and sustainability. Step two involves the practicalities theoretically seen based on the results in step one. This regards the data architecture of an organization because data is in that sense the foundation of AI. When these are well organized, real practical optimizations can be obtained. In step three, the long-term implementation of an AI system in the supply chain processes is tested based on the attributes that increase the firm performance. When in the final result a conceptualization of the individual supply chain 4.0 is achieved. Successful implementation of AI in the supply chain of a business-to-business organization is possible, taking into account the steps in the framework.

The validation of the framework included testing in terms of theoretical relevance, practical relevance, and discovering patterns between participating companies. The complete interview results are shown in Table 2. The columns of the table represent the organizations' sizes ordered in micro, medium, and large. Each row represents a different literature layer. Every organization is named by 1.1, 1.2, 1.3, etcetera. Detailed information about the interviewed organizations can be found in Table 1. The last column displays the key findings for each literature term.

5.2 Opportunities and Challenges for AI adoption

Interviewing several organizations in different fields and sizes caused differences and showed patterns in terms of technology, organization, environment, and perceived benefits of AI adoption. Intern technologies are almost used in every organization, however, in micro companies, the vast majority are not using any technology, e.g. an ERP system. Moreover, orientation to new innovative technologies is not common. Increased efficiency, decreased costs and increased flexibility appears when ‘core elements of organizational innovations’ was the topic of the interview questions. In addition, human capacity is crucial for speeding up the innovation process and the actual execution. Geopolitical effects are indirectly and directly present in all branches and organization sizes, for instance, higher energy and transportation costs. On the other hand, scarcity of diverse resources is most recognized as an environmental issue. The potential advantages of artificial intelligence are not generally known. It is important to mention the results depend on who the interviewee was, e.g. at a management level or operational level.

5.3 Entrepreneurial Orientation Capabilities

Some underestimated capabilities come from a cultural perspective in the organization. Measuring the fundamentals of pro-activeness, risk-taking and innovativeness were asked via a statement on a 5-Likert scale (Dubey et al., 2020). Overall, the questions were asked to test the entrepreneurial characteristics. All the respondents tested significantly on entrepreneurialism in the organization. According to Dubey et al. (2020), the results show a positive influence on the adoption of big data analytics powered by artificial intelligence.

5.4 Dynamic Capability View Capabilities

Similarly, the dynamic capability view is tested and it is defined as the firm's ability to implement, make and remake external and internal competencies for facing a fast-changing environment (Vogel & Güttel, 2013). In the interview, this term is divided into sensing and seizing new technological innovations. Remarkably, most organizations have an understanding and structure for testing innovation, e.g. research and development department. However, the structure for actual implementation does not exist. In addition, for that next phase, stakeholder involvement is crucial for the relevant use of technological innovation.

5.5 Practical Implementations

This section regards mainly data reporting, especially decisions and activities. An artificial intelligence system needs input for data, by providing recommendations and making relations between data inputs that cannot be done by human beings. Digital documentation of certain decisions and activities is rarely done. Likewise, the awareness of data quality does not apply. Multiple companies have the awareness that the lack of clarity in data causes issues for colleagues and so, the reliability of the data.

5.6 Improvement of Systems

In the last part of the interview, the potential for artificial intelligence tools or systems is examined. Questions in the domains reliability, responsiveness, agility, assets, and costs were asked. The domains had all sub-questions if the answer was based on sentiment or data. Most organizations answered based on sentiment in all the domains. Except for the domain assets because close to all respondents have reliable data for assets. Proper analysis concerning costs is most of the time not available. If it was the case that all the interviewees were able to answer the questions based on data, it showed that the organizations were AI-ready. As a final point, no interviewed firms have some sort of artificial intelligence system available yet in their internal supply chain.

OPPORTUNITIES AND CHALLENGES				
	1. MICRO	**2. MEDIUM**	**3. LARGE**	**KEY FINDINGS**
Technology / Technological infrastructure	1.1 No use of internal available technologies Awareness of improving technologies 1.2 Use of internal available technologies (software and Excel Awareness of improving technologies, yet no orientation 1.3 Still no use of technologies it is about physical experiences From experience, I am aware of several systems however, no orientation now	2.1 Use of internal available technologies Currently busy with orientation but want to have a lot of influence 2.2 Internal technologies are still in their infancy There is no orientation in other technologies 2.3 Almost everything is reported in technological systems There is always orientation in new technologies	3.1 Using several intern software systems, the organization is too big for a complete overview of the used systems. No active orientation in new technologies in the market 3.2 Various intern technology systems Orientation in the market and asking suppliers of 'new' technologies 3.3 All the market groups are working in the same ERP environment complemented with Excel and BI No orientation, we are working on internal behavioral change	Overall, intern technologies are used (7/9) however, in micro organizations the majority of the respondents are not using any technology (2/3). Orientation in new technologies is not common (4/9) nevertheless, this depends on which technological innovation phase the organization is settled in.
Organization (innovation)	1.1 Precisely in what to innovate and not (outsource vs. insource) 1.2 Time-saving, cheaper, and more efficient so, the innovation must be an improvement	2.1 Flexible, there is no structure for innovation. Is about knowledge, strategy, time 2.2 Practical feasibility with the potential insights it will give on the short term	3.1 Flexibility, there is a certain drive for innovation in the organization 3.2 Added value, with growing management of the organization and human capacity	Efficiency (3/9), flexibility (2/9), and almost in all organizations there is some argument about decreasing costs

	1.3 Regarding speed and efficiency, most innovations are caused by outsourcing by partners	2.3 Must lead to efficiency, effectiveness, and cost saving	3.3 Support and acceptance in the whole organization, human capacity, and fit for future	The lack of human capacity is especially present in the larger companies (2/3)
Transforming / Environment	1.1 Covid-19 and Ukraine war are external influences on: scarcity in supply sources 1.2 Supplier(planning), transport(quality) costs, customer payment of goods 1.3 Scarcity in resources, politics, and sustainability of the products	2.1 The issues of the day, scarcity in the market, increase in energy costs 2.2 Delivery time, supplier prescriptions, global politics 2.3 Scarcity in resources, transportation, and human capital	3.1 Scarcity of resources, transport costs, clients who have certain unreal expectations 3.2 Scarcity, production capacity, and (see)transportation 3.3 Scarcity, priority of suppliers, and delivery times of suppliers	Scarcity on the supply side of, for instance, resources is the most recognized environmental issue (7/9) Geopolitical influences are also well represented and in all respondent organizations indirect or direct involvement in, for example, energy costs and transportation costs
Perceived benefits	1.1 No, the disadvantages make no odds against the advantages 1.2 Yes, commercially but technically no idea 1.3 Not yet, but for more clarity and overview the data input need to be organized	2.1 Yes, we want to work more from data and logic 2.2 Yes, because of the youth in the organization 2.3 No, unconscious we making probably already use of AI	3.1 No, awareness however, unconscious there is a certain AI awareness 3.2 Not on the departments, in the board there is awareness 3.3 No, till your invitation not	Perceived benefits of AI are not known at all (5/9) however, this depends on the level (e.g. operations or management) of whom you will ask these questions
		CAPABILITIES		
		ENTREPRENEURIAL ORIENTATION		
	1. MICRO	**2. MEDIUM**	**3. LARGE**	**KEY FINDINGS**
Summary of entrepreneurial	1.1 0.63 1.2 0.53 1.3 0.63	2.1 0.60 2.2 0.57 2.3 0.60	3.1 0.67 3.2 0.67 3.3 0.60	Overall, all the participating organizations have a significant amount of

orientation results				entrepreneurial characteristics in the company This result addresses something about the influences on the adoption of big data analytics powered by artificial intelligence (Dubey et al., 2020), in this case, the result is significant
Pro-activeness	1.1 Agree Agree 1.2 Agree Disagree 1.3 Agree Disagree	2.1 Neutral Disagree 2.2 Agree Neutral 2.3 Agree Strongly disagree	3.1 Agree Agree 3.2 Agree Neutral 3.3 Disagree Disagree	
Risk-taking	1.1 Agree Strongly disagree Disagree 1.2 Disagree Disagree Disagree 1.3 Disagree Agree Disagree	2.1 Agree Neutral Disagree 2.2 Strongly disagree Neutral Disagree 2.3 Neutral Disagree Agree	3.1 Agree Strongly disagree Agree 3.2 Disagree Neutral Agree 3.3 Agree Agree Agree	
Innovativeness	1.1 Agree 1.2 Agree 1.3 Strongly agree	2.1 Agree 2.2 Agree 2.3 Agree	3.1 Neutral 3.2 Agree 3.3 Disagree	
	DYNAMIC CAPABILITY VIEW			
	1. MICRO	**2. MEDIUM**	**3. LARGE**	**KEY FINDINGS**
Sensing	1.1 Try and error with technological opportunities that are identified as interesting 1.2 The underpinning of arguments based on the benefits of efficiency and finance 1.3 Increase in efficiency, overview, and the	2.1 Time-consuming, because of the lack of time and knowledge 2.2 No structure, department-specific, and always open to ideas 2.3 Taken into account the relevance with the board, sharing experiences with other organizations	3.1 If it is innovative and the chance is analyzed as an opportunity there will be action 3.2 Argumentation why you want to take the initiative with management, board, and the employees involved 3.3 Reactive, the biggest challenge is to create	These results suggest in almost all the answers on the understanding of the dynamic capabilities of the organization Nevertheless, the organizations with no structure (5/9) are having an understanding but no framework for optimizing the structure

	decreased error sensitivity		stakeholder involvement	
Seizing	1.1 Informing, inviting ambassadors, and validating expertise 1.2 Knowledge inhouse, can we insource the knowledge, and is that not too costly 1.3 Orientation in implementation of automation systems because of the growth of the organization	2.1 Bring in expertise and take time for the training of employees 2.2 Creating a project team with charters for a specific innovation goal 2.3 Project capacity in the form of humans	3.1 Awareness in the organization of the benefits of the opportunities 3.2 Create support by all the stakeholders involved 3.3 The motivation of people in the operation and again the stakeholder involvement in innovation projects	Stakeholder involvement could be seen as a trend (8/9) in the seizing of the mobilizing of the resources for opportunities
	PRACTICAL IMPLEMENTATIONS			
	1. MICRO	**2. MEDIUM**	**3. LARGE**	**KEY FINDINGS**
Documentation	1.1 Documented in Excel, is a disaster 1.2 Official notifications are documented, and other activities and decisions are not stored 1.3 No documentation only reporting via phone calls	2.1 No documentation of decisions and activities only via mail/phone/meeting 2.2 KPI audits by suppliers but the documentation is currently in development 2.3 There is no reporting in the operations, in the procurement departments there is reporting	3.1 Intern projects on notes and action points 3.2 BI reports and structural meetings however, no intern reporting 3.3 Intensive collaboration from procurement caused reporting and steering of propositions	Striking in the answers to this question are that in some companies still, no documentation is about decisions and activities (7/9)
Data quality	1.1 Flat organization so, when it is unclear the person will contact the colleague who reported	2.1 Lack of clarity because the end-user is not involved 2.2 Data reliability is an issue	3.1 The organization is not internally reporting findings 3.2 Reports are in some cases be forgotten so,	Attention to data quality is not done which causes issues like lack of clarity and data reliability

	1.2 Quality is understandable but not optimal, need to be better 1.3 No, because we have no documentation in that way	2.3 Not clear for everyone, the reporting is not complete historically wise	that is not visible to colleagues 3.3 Reactive and learning by doing without reporting is an issue	
	IMPROVEMENT OF SYSTEMS			
	1. MICRO	**2. MEDIUM**	**3. LARGE**	**KEY FINDINGS**
Reliability	1.1 Sentiment, unavailability of resources 1.2 Sentiment, based on expertise 1.3 Sentiment, the quality is no issue nevertheless, purchasing is based on sentiment as well	2.1 Sentiment, not the right data and systems 2.2 Sentiment, customer specific is sometimes the challenge with prescriptions 2.3 Depending on the project, there is a lot of transparency with the suppliers so, in that way based on data	3.1 Somewhere in between data and sentiment because in certain projects we work in a certain frame 3.2 In between data and sentiment, it depends on the person who is responsible for the tasks 3.3 Anything in between, the multidisciplinary collaboration is will hopefully support the more data-driven reasoning	The sentiment (5/9) Somewhere in between data and sentiment (4/9)
Responsiveness	1.1 Data, active request of prognoses by clients 1.2 Sentiment, very transparent and can act quickly with customers 1.3 Data, the large stock gives us more space and flexibility	2.1 Sentiment, fast delivery is a high priority 2.2 Sentiment, early involvement of partners 2.3 Data, the interaction between sales and operations is clear	3.1 Sentiment, the internal monitoring of processes is not monitored at all 3.2 Sentiment, is all about trust in the partners, is a lot of reactive handling 3.3 Sentiment, reacting to actual problems and not foreseeing those	The sentiment (6/9) Data (3/9)

Agility	1.1 Based on data and sentiment because of the small scale of the organization 1.2 Starting with sentiment and continuing with data, there is no reporting 1.3 Incorporate alternative suppliers for all resources, based on data	2.1 Sentiment, actions provoke responses 2.2 Sentiment depends on supplier and commodity 2.3 Sentiment depends on the internal person and how fast the organization acts	3.1 The sentiment is about external influences that are not taken into account in actions 3.2 The sentiment is all about the expertise of the organization, we can adapt and react very quickly 3.3 Sentiment, again reactive so, not effective	The sentiment (7/9) Data (2/9)
Assets	1.1 Based on data, is based on the dispatch time of the clients 1.2 Based on data, in the software is this real-time reported (throughput speed) 1.3 Sentiment, the reason for that is the big stock the organization has this is a weakness but on the other hand also a strength	2.1 Data, we ask customers about future orders and see trends in the historic data 2.2 Data, because we are still working on a project base inventory 2.3 Data, based on the security in the stock, e.g. we make forecasts	3.1 Data is about efficiency and stock 3.2 Data, the stock is monitored and managed between guidelines 3.3 Data, the internal stock is been monitored	The sentiment (1/9) Data (8/9)
Costs	1.1 Sentiment, time is costly we do not map that 1.2 Financially is based on data combination with service is based on sentiment 1.3 Sentiment, not all the supply chain processes are taken into account when the costs are calculated	2.1 Sentiment, a lot of waste caused by little insight 2.2 Sentiment, a lot of inefficiency in cooperation with our suppliers 2.3 Data, a lot of data of costs in the supply chain reason for that is the business model	3.1 There are a lot of opportunities to improve efficiency based on sentiment 3.2 Data, a lot of overhead we are not cheap but the service quality is high 3.3 Sentiment, the quantification is in the organization a struggle	The sentiment (6/9) Data (3/9)

Table 2 Results of validation interviews.

6. DISCUSSION OF THE FRAMEWORK OF AI PRACTICE IN THE SUPPLY CHAIN

The extension to what AI capabilities can potentially lead to a successful AI implementation in the supply chain is something that still could be considered. Nevertheless, the results of the systematic literature review led to this framework, which is validated by firm interviews, the relevance, and practicalities of the research. The framework can be seen as a certain step approach in layers, so e.g. step one is the first layer (shown in blue), step two is the second layer (shown in red), and, step 3 is the third layer (shown in yellow). In line with the feedback of the firms, the results suggest that the capabilities enumerated in Figure 3 add value to the supply chain of a business-to-business organization.

The opportunities and challenges are regardless of size and industry the same for all the respondents. This means that in every organization results can be obtained in terms of technology, organization, environment, and perceived benefit of AI adoption. Nevertheless, focusing on the dynamic capability view, it seems like larger-sized companies have a benefit in seizing and sensing. Important to mention is every firm can achieve some results independently in each literature block (shown in green in Figure 3). Besides, the practical implementations seem to be more beneficial for larger-sized organizations. This can be explained by the fact that a larger firm has already developed some internal capabilities for technological innovation caused by experience. However, in the improvement of systems phase, there are some differences in the tested attributes. Larger organizations act more on data in reliability cases whereas micro organizations are acting more on data in responsiveness activities. Agility is overall more based on sentiment even though, logical thinking addresses that smaller organizations have an advantage in this attribute. The question about the assets is overall argued based on data, the total costs of the supply chain are based on sentiment. In my opinion unexpected, because costs are mainly the reason why some prices of products are settled.

The results of the framework are built on existing literature. In addition, the interviews are the practical validation of the research. The data contribute in that way to a clearer understanding of the paper. Moreover, it is possible to give the organizations a certain position where they can state their readiness for the artificial intelligence adoption position. Giving accurate advice to the participating companies on the AI readiness criteria is one of the most relevant results of the research.

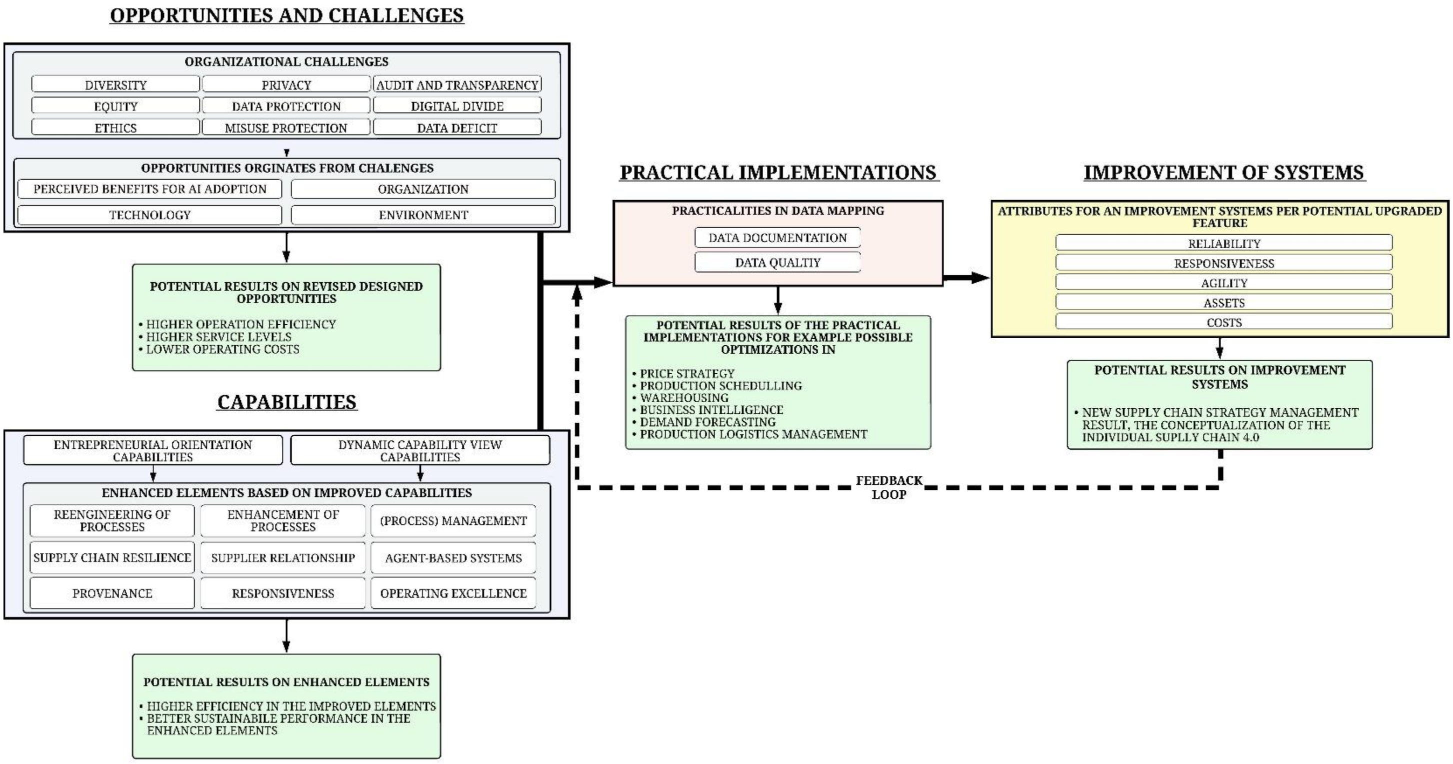

Figure 3 Framework for AI implementation in the supply chain of a B2B company.

7. CONCLUSION

The framework in Figure 3 represents how a business-to-business organization that adds value to its products can make the organization ready for the implementation of artificial intelligence systems or tools in the supply chain. This research aimed for explicitly practical implementation. Though, most organizations are not aware of artificial intelligence. This thesis shows that it is essential for organizations to prepare for AI applications. Based on this research, it is easier to understand the criteria organizations have to meet for optimal data use and possibly artificial intelligence optimizations in the supply chain. In addition, particular the qualitative research showed that it was possible to meet certain criteria in several phases or steps. Phase 1 is shown in blue, phase 2 in red, and phase 3 in yellow. Besides, in every phase, the organization can obtain results, shown in green. However, optimal results will only be reached when all the criteria will be met. It cannot be ruled out that optimal conditions in all phases will lead to fewer struggles in the next phases of the framework. Subsequently, internal and external environmental values (opportunities and challenges) and more cultural values (capabilities) have a significant impact on the actual use of data-drivenness in the supply chain. The impact of, for instance, more data-driven decision-making will hypothetically optimize certain essential aspects of the supply chain. Practical implementation of the criteria in the framework will eventually confirm all the addressed aspects. The short-term need is to increase the reporting of certain decisions and activities, and data documentation. Thereafter, maintaining data quality high and keeping the data on a recognized level for every employee involved. This is a continuing process, that is why the feedback loop is shown in the framework. The long-term improvement will be how organizations will interpret and decide on the data that is internally or externally delivered. Ultimately, the goal is to implement certain AI systems in the supply chain that make, e.g. better relations and recommendations. Based on these conclusions, practitioners should consider the standards in the framework per layer and phase. That being the case there is still some expertise in business, data and later on and artificial intelligence needed.

8. STRENGTHS, LIMITATIONS, AND FUTURE RESEARCH

8.1 Strengths

The strength of the research is the combination of a solid systematic literature review that relates to relevant theory. Validating the framework with extensive interviews with businesses in several B2B branches improved the research significantly. Moreover, the multiple perspectives gave insights into the research and expand its relevance. The willingness of the organization to participate demonstrates the interest in the topic. In addition, all the feedback on the thesis positively developed the research.

8.2 Limitations

Nevertheless, a limitation is that some answers are industry-dependent. In addition, the questions could be in some way a bit interpretable per respondent. However, this is taken into account in the processing of the answers. The methods that are used for processing the articles are more common in qualitative research, but it is also possible in grounded theory research. Additionally, the focus in the articles was not particular on the business-to-business field. The limited time when the research is conducted is a limitation as well for instance when the time was unlimited more companies were able to participate in the interviews. In addition, the interviews are conducted in Dutch and translated to English. There is a chance that this caused some differences in processing the interview results. The fact that the research is done by only one researcher is a limitation as well, it can be that this caused biases and heuristics.

8.3 Future Research

The focus of this research is on the supply chain, future research can expand the focus. Furthermore, the next research can investigate how to implement AI in the supply chain to, be more practical and focused. In this research, organizations can set all the capabilities and criteria right for hypothetically AI implementation in the supply chain. The actual implementation is not tested even as, potential systems.

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10. APPENDICES

Appendix A

The keyword research that leads to the AI capability dimensions are shown in the table below:

AI (Helm et al., 2020)	SUPPLY CHAIN RISK MANAGEMENT AND ARTIFICIAL INTELLIGENCE (Baryannis et al., 2018)	AI CAPABILITIES (California Management Review - Volume 61, Number 4, Aug 01, 2019)	ORGANIZATIONAL AI CAPABILITIES (Brock & von Wangenheim, 2019)	AI CAPABILITY DIMENSIONS
Big data	Mathematical programming	data analysis	Data Science skills	AI literacy
Machine learning	Network-based models	human capital	Lack of skilled staff/digital knowledge	
Deep neural networks	Multi-agent systems	human resource ethics	Engaged staff	
Deep learning	Automated reasoning	hiring and recruitment	Integrated data management	AI technology alignment
	Machine learning and Big data	information systems	Digital processes	
		human resources	Integration of old/new technology	
		feeling intelligence	Digital strategy	AI business eco-system
		human-machine collaboration	Open innovation eco-systems	
		job design	Technology partner support	
		decision-making	Organizational agility	AI organizational practice
		algorithms	Operational efficiency	
		organizational structure	Offering competitiveness	
		delegation	Supportive culture	AI ethicality
		artificial swarm intelligence	Leadership support	
		crowdsourcing		
		prediction markets		
		collective intelligence		
		human-in-the-loop AI		
		management		
		customer relationship management		
		marketing		
		personalization		

Table A.1 Keyword research that led to the AI capability dimensions.

Appendix B

Systematic Literature Review

Identification

In the first stance, it is important to make a strategy before starting doing a systematic literature review. The strategy was to segment the topic into several parts. Decomposing the topic gave four terms: artificial intelligence, supply chain management, capabilities, and business-to-business. When finding some synonyms of the terms and searching it gave not that many results namely, 43 articles. That is why it was better in terms of results to minimize the terms to three, with removing business-to-business.

Considering the fact of finding more reliable terms for especially artificial intelligence and supply chain. While these could be interpreted in different kinds of ways and are quite general terms. Finding systematic literature on artificial intelligence relating to this assignment was useful for selecting the right concepts (Schachner et al., 2020). In addition, the same strategy is used for supply chain management (J. Zhang et al., 2020). Relevant synonyms for capabilities were found in a synonym database.[4] Table B.1 is the syntax described which is used for the identification phase, which resulted in 5,745 documents.

ARTIFICIAL INTELLIGENCE	**CAPABILITIES**	**SUPPLY CHAIN MANAGEMENT**
AI	Abilities	Logistics
Machine learning	Opportunities	Warehousing
Deep learning		Inventory management
Neural network		Procurement
Neural networks		
Algorithm		
Predictive analyses		
Supervised learning		
Unsupervised learning		

Table B.1 Syntax used for the systematic literature review.

Furthermore, limiting the search to final publications, English language, and document types to articles and limiting the publications dates to 2019, 2020, 2021, and 2021 resulted in 1,026

[4] https://www.thesaurus.com/

documents. Perfect for more speciation by limiting some irrelevant subject areas. In Table B.2 you can view the limitation added to the search. This could be covered between the identification and screening phase, resulting in 488 documents.

LIMITATIONS			
Computer science	Engineering	Business, management, and accounting	Decisions science
Multidisciplinary	Social sciences	Multidisciplinary	Social sciences
Materials science	Materials science	Environmental science	Economics, econometrics, and finance
Neuroscience	Psychology		

Table B.2 Limitations used for the systematic literature review.

In sum, the following syntax is used in the intertwined database of Scopus and FIND UT Library:

TITLE-ABS-KEY(("artificial intelligence" OR "AI" OR "machine learning" OR "deep learning" OR "neural network" OR "neural networks" OR "algorithm" OR "predictive analytics" OR "supervised learning" OR "unsupervised learning") AND (capabilit* OR abilit* OR opportunit*) AND ("supply chain management" OR "logistics" OR "warehousing" OR "inventory management" OR "procurement")) AND (LIMIT-TO (PUBSTAGE,"final")) AND (LIMIT-TO (DOCTYPE,"ar")) AND (EXCLUDE (SUBJAREA,"MEDI") OR EXCLUDE (SUBJAREA,"MATH") OR EXCLUDE (SUBJAREA,"BIOC") OR EXCLUDE (SUBJAREA,"PHYS") OR EXCLUDE (SUBJAREA,"AGRI") OR EXCLUDE (SUBJAREA,"EART") OR EXCLUDE (SUBJAREA,"ENER") OR EXCLUDE (SUBJAREA,"CHEM") OR EXCLUDE (SUBJAREA,"CENG") OR EXCLUDE (SUBJAREA,"PHAR") OR EXCLUDE (SUBJAREA,"VETE") OR EXCLUDE (SUBJAREA,"IMMU") OR EXCLUDE (SUBJAREA,"ARTS") OR EXCLUDE (SUBJAREA,"HEAL") OR EXCLUDE (SUBJAREA,"NURS") OR EXCLUDE (SUBJAREA,"DENT")) AND (LIMIT-TO (PUBYEAR,2022) OR LIMIT-TO (PUBYEAR,2021) OR LIMIT-TO (PUBYEAR,2020) OR LIMIT-TO (PUBYEAR,2019)) AND (LIMIT-TO (LANGUAGE,"English"))

Screening
Unfortunately, automation in the initial screening phase of a systematic literature review is not allowed in the assignment. However, the use of the same features of titles and abstracts are used in this research to the exclusion of the reports (Bekhuis & Demner-Fushman, 2010). Excluding is based on environmental impact, diseases, and hard mathematical articles. This resulted in 45 articles.

Eligibility
By reading critically the abstracts, introduction, and conclusion 14 articles were excluded. Due to several reasons such as focusing on the wrong topic, out of scope, or because the article is not accessible. Studies eligible for qualitative synthesis are 31 articles.

Excluded articles:

IoT monitory system based smart trash management → Not relevant because this article is focusing on the IoT

Efficient prediction of big data analytics using various approaches → Not accessible

Exploring the opportunity of digital voice assistants in the logistics and transportation industry → Not accessible

Smart logistics based on the internet of things technology: an overview → Not relevant because this article is focusing on the IoT

An Application of Data Envelopment Analysis and Machine Learning Approach to Risk Management → Not relevant because this article is out the scope of focusing on risk management in general

A data fusion approach to predict shipping efficiency for bulk carriers → Not relevant because the article is about transportation

The effect of accounting information systems to facilitate supply chain management in retail companies: Evidence from Indonesia → Not relevant because this article is out of the scope

An intelligent logistics service system for enhancing dispatching operations in an IoT environment → Not relevant because too much focus on IoT

An integrated online pick-to-sort order batching approach for managing frequent arrivals of B2B e-commerce orders under both fixed and variable time-window batching → Not relevant and too specific about pick-to-sort order batching

Leveraging task modularity in reinforcement learning for adaptable industry 4.0 automation → Not accessible

A variable neighborhood search for flying sidekick traveling salesman problem → Not relevant according to the scope of the research

Location and allocation problem for spare parts depots on integrated logistics support → It is about a location problem of depots so, to specific according to this assignment.

Stored Grain Inventory Management Using Neural-Network-Based Parametric Electromagnetic Inversion → Not relevant because to specified in the product discussed in this article.

Using Bayesian Networks to forecast spares demand from equipment failures in a changing service logistics context → Not relevant, to specific forecasting spare demand from equipment failures

Inclusion

TITLE	1st ORDER CONCEPTS	2nd ORDER THEMES	AGGREGATE DIMENSIONS
A human-centric perspective exploring the readiness towards smart warehousing: The case of a large retail distribution warehouse (Mahroof, 2019)	*"The research provides practical insights which are of relevance to managers, their environment, and skills. The findings reveal various opportunities and potential barriers of AI adoption within warehouse context."* *"Through the findings and insights from operational management, this research improves the understanding of the current challenges associated with smart warehousing by acknowledging the critical role of organizational infrastructure, skills, mindsets, and AI exposure for AI technology adoption."*	Practical insights of opportunities and barriers according to the dimensions of organizational infrastructure, skills, mindsets and AI exposure for AI technology adoption.	Supply chain AI opportunities and challenges
Applications of smart technologies in logistics and	*"The applications have covered a wide spectrum, including public transport, production shop floors,*	Discuss the contributions and challenges of AI/BD/ML with the support of IoT/blockchain.	

transport: A review (Chung, 2021)	*warehouses, last mile deliveries, and so on. Enabled by AI/ BD/ML with the support of IoT/blockchain, autonomy provides us with a lot of significant benefits and contributions."*		
Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice, and policy (Dwivedi et al., 2021)	*"The study brings together the collective insight from a number of leading expert contributors to highlight the significant opportunities, realistic assessment of impact, challenges, and potential research agenda posed by the rapid emergence of AI within a number of domains: business and management, government, public sector, and science and technology. This research offers significant and timely insight to AI technology and its impact on the future of industry and society in general, whilst*	An overview of opportunities and challenges of AI. Based on the DEEP-MAX scorecard under the TAM-DEF framework. (Dwivedi et al., 2021)	Supply chain AI opportunities and challenges

	recognizing the societal and industrial influence on the pace and direction of AI development."		
Stochastic optimization models for joint pricing and inventory replenishment of perishable products (Azadi et al., 2019)	*"This work analyzes joint pricing and inventory management decisions for age-dependent perishable products in a periodic-review inventory system."*	The opportunities to increase profitability and reduce waste for perishable products.	
The four smarts of Industry 4.0: Evolution of ten years of research and future perspectives (Meindl et al., 2021)	*"We show that research opportunities are concentrated in the interfaces between the different smart dimensions. Our findings support the vision of Industry 4.0 as a concept transcending the Smart Manufacturing field, thus creating opportunities for synergies with other related fields."*	SMART opportunities based on a conceptual model of digital transformation.	Supply chain AI opportunities and challenges
A hybrid ensemble and AHP approach for resilient supplier selection (Hosseini & Khaled, 2019)	*"This paper proposed a hybrid ensemble and AHP approach in which the ensemble method is used to calculate the resilience value of*	A method to calculate the resilience value of potential suppliers on the notion of the	Capabilities of AI supply chain improvement

	potential suppliers based on the notion of their absorptive, adaptive, and restorative capacities. Eight contributors to the resilience of suppliers were identified, analyzed, and ranked using the ensemble method. We found that robustness, reliability, and rerouting are the most important enablers of supplier resilience."	suppliers' adaptive, absorptive, and restorative capacities.	
	"The findings of this study can be served as a good starting point for assessing impacts of resilience in supply chains."		Capabilities of AI supply chain improvement
Assessment of Company Competitive Advantage Strategy Through Supply Chain (Medvedeva et al., 2020)	*"The article discusses the methodological aspects of an enterprise competitiveness improvement based on the strategic development of supply chain management."*	Discusses the trends and aspects of improvements with supply chain management measures.	

	"Our model confirmed the relationship between supply chain management measures (strategic partnership with the supplier, customer relationship management, informing level, informing quality and procrastination) and a competitive advantage's component."		
Big data analytics and artificial intelligence pathway to operational performance under the effects of entrepreneurial orientation and environmental dynamism: A study of manufacturing organisations (Dubey et al., 2020)	*"These findings extend the dynamic capability view and contingency theory to create better understanding of dynamic capabilities of the organisation while also providing theoretically grounded guidance to the managers to align their entrepreneurial orientation with their technological capabilities within their firms."*	The research is about the theoretically understanding of the technological capabilities of a firm. Offering some contributions to the managerial practice and theory.	Capabilities of AI supply chain improvement

Blockchain technology in supply chain operations: Applications, challenges and research opportunities (Dutta et al., 2020)	*"SCM has entered the big data era, and blockchain technology has emerged as a disruptive technology. It is commonly believed that blockchain has a huge potential to transform the SCs, both global and local, by improving operational efficiency, data management, responsiveness, transparency and smart contract management."*	The article is focusing about the improvement dimensions of an implementation of a blockchain technology as an AI adoption.	Capabilities of AI supply chain improvement
Economic Business Partnerships Within Industry 4.0: New Technologies in Management (Portna et al., 2021)	*"In terms of Industry 4.0, the market has a significant impact on companies. In order to maintain their viability and development, company executives must conduct business considering the strategic interaction with key stakeholders."*	The report is focusing on improving the supplier relationship management process, strategic interaction, increasing the efficiency and competitiveness of an organization.	
Enhancing Vendor Managed Inventory Supply Chain Operations Using Blockchain	*"We present cost and security analysis incurred by the stakeholders in the supply chain.*	It's about a blockchain-based solution for supply chain	

Smart Contracts (Omar et al., 2020)	*Adopting a blockchain-based solution to VMI operations in supply chains is economically viable and provides a streamlined, secure, trusted, and transparent mode of communication among various stakeholders."*	management based on AI principles.	
Evolution of Operations Management Research: from Managing Flows to Building Capabilities (F. Zhang et al., 2020)	*"Based on three flows of material, information, and financial flows." "Finally, we argue that, to achieve operational efficiency, resilience, and sustainability in the Industry 4.0 era, firms should build (or strengthen) three new capabilities: Connectivity, Clarity, and Continuity."*	Three new trend capabilities for the future to achieve efficiency, resilience, and sustainability.	Capabilities of AI supply chain improvement
Identification and classification of materials using machine vision and machine learning in the context of industry 4.0 (Penumuru et al., 2020)	*"A novel generalized methodology based on Support Vector Machine had been developed to accurately identify and classify flat materials being machined in a typical*	Based on machine vision and machine learning an incorporated perception of decision making cognitive abilities is created.	

	manufacturing environment. This was accomplished using machine vision and machine learning techniques."		
Research on logistics supply chain of iron and steel enterprises based on block chain technology (Yang et al., 2019)	*"At present, the service trading system of steel logistics industry is highly centralized, with poor collaborative ability. Information flow, capital flow and logistics need to be certified by logistics center nodes. It cannot achieve information transparency, traceability and tampering, and the information security of customers cannot be effectively guaranteed."*	Via the perspective of blockchain technology in supply chain logistics information resource management analyses from attribute, object and function dimensions are done. In addition, they look how to implement an algorithm to improve the discussed dimensions.	Capabilities of AI supply chain improvement
Will bots take over the supply chain? Revisiting agent-based supply chain automation (Xu et al., 2021)	*"Agent-based systems have the capability to fuse information from many distributed sources and create better plans faster. This feature makes agent-based systems naturally suitable to address the*	Providing a framework of agent-based system integration in supply chain management.	

	challenges in Supply Chain Management (SCM).”		
A machine learning based approach for predicting blockchain adoption in supply Chain (Kamble et al., 2021)	*“The literature has identified in the past that the institutional factors that include the technological, organizational, and environmental factors influence technology adoption. The present study conceptualized blockchain technology as a dynamic capability that every organization should possess to remain competitive and analyzed the blockchain adoption behavior of the organizations.”* *“The findings support the underlying theory of dynamic capability by identifying competitor pressure, partner readiness, perceived usefulness, and perceived ease of use as the most influencing factors for blockchain adoption.”*	An AI decision support system based on dynamic capability by the identified competitor pressure, partner readiness, perceived ease of use and perceived usefulness for blockchain adoption.	Practical AI supply chain implementation

A Middleware Platform for Intelligent Automation: An Industrial Prototype Implementation (Coito et al., 2020)	*"The proposed platform in the respective implementation example handles the real-time requirements of dynamic scheduling in two major fronts. With automatic data preparation and structuring steps and relying on a communication architecture that is not hierarchical."*	Foundation of how to implement a platform for intelligent automation on the dimensions of automatic data preparation and communication architecture that is not hierarchical.	
Big Data Velocity Management–From Stream to Warehouse via High Performance Memory Optimized Index Join (Naeem et al., 2020)	*"Efficient resource optimization is critical to manage the velocity and volume of real-time streaming data in near-real-time data warehousing and business intelligence. This article presents a memory optimisation algorithm for rapidly joining streaming data with persistent master data in order to reduce data latency."*	A practical contribution about an algorithm optimisation for managing the velocity and volume of data in warehousing and business intelligence	Practical AI supply chain implementation

Demand Forecasting Tool For Inventory Control Smart System (Benhamida et al., 2021)	*"With the availability of data and the increasing capabilities of data processing tools, many businesses are leveraging historical sales and demand data to implement smart inventory management systems. Demand forecasting is the process of estimating the consumption of products or services for future time periods."*	Demand forecasting and price strategy optimization based on data.	
Predictive big data analytics for supply chain demand forecasting: methods, applications, and research opportunities (Seyedan & Mafakheri, 2020)	*"In this survey, we investigate the predictive BDA applications in supply chain demand forecasting to propose a classifcation of these applications, identify the gaps, and provide insights for future research. We classify these algorithms and their applications in supply chain management into time-series forecasting, clustering, K-nearest-neighbors, neural*	A review of applications of predictive big data analytics in supply chain demand forecasting.	Practical AI supply chain implementation

	networks, regression analysis, support vector machines, and support vector regression."		
Production Logistics Management of Industrial Enterprises Based on Wavelet Neural Network (Liang, 2020)	*"With an efficient production logistics system, intelligent manufacturers can reduce the investment in production, improve the stability and self-repair ability of production logistics, and strike a perfect balance between production scheduling and production logistics."*	Provides theoretical support for real-time optimization for production logistics management and production scheduling.	Practical AI supply chain implementation
The potential of emergent disruptive technologies for humanitarian supply chains: the integration of blockchain, Artificial Intelligence and 3D printing (Rodríguez-Espíndola et al., 2020)	*"The analysis presented shows the potential of the framework to reduce congestion in the supply chain, enhance simultaneous collaboration of different stakeholders, decrease lead times, increase transparency, traceability and accountability of material and financial resources, and allow*	Analysis of technique combinations (Blockchain, AI, 3D printing) can provide suitable answers of practical challenges.	

	victims to get involved in the fulfilment of their own needs."		
A systematic literature review of supply chain decision making supported by the Internet of Things and Big Data Analytics (Koot et al., 2021)	*"We can conclude that typically measuring devices are integrated with more traditional ICT infrastructures to either visualize the current way of operating, or to better predict the system's future state. Neural networks, statistics, and BI techniques are the most popular techniques applied within IoT networks, which empowers supply chain decision makers with real-time monitoring capabilities at an operational level."*	IoT networks are based on neural networks, statics and BI techniques which empowers supply chain decision makers.	Practical dimensions to create a decision support system in the supply chain
Advancing Logistics 4.0 with the Implementation of a Big Data Warehouse: A Demonstration Case for the Automotive Industry (Silva et al., 2021)	*"Due to the increase in data volume, velocity, and variety, organizations are now looking to their data analytics infrastructures and searching for approaches to improve their decision-making*	An approach to improve decision-making capabilities in an organization with big data and machine learning.	

	capabilities, in order to enhance their results using new approaches such as Big Data and Machine Learning. The implementation of a Big Data Warehouse can be the first step to improve the organizations' data analysis infrastructure and start retrieving value from the usage of Big Data technologies. Moving to Big Data technologies can provide several opportunities for organizations, such as the capability of analyzing an enormous quantity of data from different data sources in an efficient way. However, at the same time, different challenges can arise, including data quality, data management, and lack of knowledge within the organization, among others."		Practical dimensions to create a decision support system in the supply chain

An adaptive network-based fuzzy inference system to supply chain performance evaluation based on SCOR® metrics (Lima-Junior & Carpinetti, 2020)	*"This study proposed a new intelligent system for supply chain performance evaluation based on the combination between the SCOR® level 1 and 2 metrics with ANFIS neuro-fuzzy models." "Use of the proposed system allows managers to evaluate the effectiveness of their strategies, thus contributing to the focus company being more proactive in the search for better performance results. Over time, managers can switch the metrics used in the proposed evaluation system."*	A new intelligent system for supply chain performance evaluation based on the evaluation of the effectiveness of their strategies to gain more proactiveness in the search for performance results.	Improvement of system for supply chain performance
An integrated optimization model and metaheuristics for assortment planning, shelf space allocation, and inventory management of perishable products: A real application (Sajadi & Ahmadi, 2022)	*"In this research, we considered a retailing problem seeking for maximizing its profit from the sales of the principal or substituting products. This problem considers the perishability of the products*	The problem of perishability of products, considered by uncertainty of the retailer' planning, pricing, assortment planning, shelf space allocation and inventory planning.	

	and it incurs a cost for destroying the products if they are not sold. The model proposed by this study has several opportunities for expansion, considering the uncertainty in demand could significantly improves the retailer' planning. Pricing based on assortment planning, shelf space allocation and inventory planning."		Improvement of system for supply chain performance
Forecasting Parameter Strategy Using Data Analytics in Supply Chain Management (Chandrasekaran et al., 2021)	*"Parameters like Demand, Market Values, Customer behavior, weather fluctuations, etc., are to be considered to make out a plan over supply criteria." "Efforts are made to recognize the capabilities of Big-Data applications to make valuable forecasts by establishing a high*	The paper suggesting a proposed an optimal strategy for maintaining the optimal supply chain.	Supply chain AI strategy management

	degree of Reliability and implementing related data."		
Multi-criteria evaluation of real-time key performance indicators of supply chain with consideration of big data architecture (Dev et al., 2019)	*"Within the big data framework, the proposed model can be used as a decision support tool by the companies to evaluate their KPIs in a real-time dynamic system."*	The research is about a big data architecture providing an effective approach of supply chain management, the basis of AI.	
ORGANIZATION THE INFORMATION SUPPORT OF FULL LOGISTIC SUPPLY CHAINS WITHIN THE INDUSTRY 4.0 (Rahimi et al., 2020)	*"It is proposed to modernize the mathematical and information support of complete logistic supply chain by supplementing the currently used AnyLogic modeling environment with artificial intelligence and knowledge engineering. The technology of multi-agent systems (MAS) has been used as such a tool."*	Provides several useful theories and methods how to modernize the supply chain.	Supply chain AI strategy management
Peeking into the void: Digital twins for construction site logistics (Greif et al., 2020)	*"Leveraging new information sources for the redesign of core business processes drastically*	An system design and system information flow how to digitalize the supply chain.	

	increases the complexity of operational decision-making. To tap into these opportunities, we design and implement a decision support system for silo dispatch and replenishment activity."		
Supply Chain 4.0: A Survey of Cyber Security Challenges, Solutions and Future Directions (Sobb et al., 2020)	*"Supply chain 4.0 denotes the fourth revolution of supply chain management systems, integrating manufacturing operations with telecommunication and Information Technology processes."* *"This paper explains the nature of the military supply chains 4.0 and how it uniquely differs from the commercial supply chain, revealing their strengths, weaknesses, dependencies and the fundamental technologies upon which they are built."*	Provides technology-specific approaches and conceptual architecture of supply chain 4.0.	Supply chain AI strategy management

Table B.3 Structure of the processing procedure in the articles that were the result of the systematic literature review.

Appendix C

Step 0

1. What is your job function?

……………………………………………………………………………………………

2. What is your definition of the supply chain?

……………………………………………………………………………………………

3. What is your definition of artificial intelligence?

……………………………………………………………………………………………

Step 1 (Mahroof, 2019)

Technology

1. Which kind of available technologies are you currently using for improving the organizational productivity of the internal supply chain?

……………………………………………………………………………………………

2. Which kind of available technologies are you currently aware of for improving the organizational productivity of the supply chain?

……………………………………………………………………………………………

Organization

3. What does an innovation process look like in the organization (firm size, scope, managerial structure, human resources capabilities)?

……………………………………………………………………………………………

Transforming / Environment

4. What kind of external influences are there (according to industry and competitors) for access to resources supplied by others?

……………………………………………………………………………………………

Perceived benefits

5. Is there any kind of internal recognition of the relative advantage AI technology can provide the organization?

……………………………………………………………………………………………

Step 2 (Dubey et al., 2020)

Entrepreneurial orientation

6. To what extent does our organization: (1 ¼ strongly disagree, 2 ¼ disagree, 3 ¼ not sure, 4 ¼ agree, 5 ¼ strongly agree)

Pro-activeness

- Firmly believe that a change in the market creates a positive opportunity for us [EO1]
- Team members tend to talk more about opportunities rather than problems [EO2]

Risk-taking

- Value the orderly and risk-reducing management process much more than the leadership initiatives for change [EO3]
- Senior managers like to “play it safe” [EO4]
- Top managers around here like to implement plans only if they are certain [EO5]

Innovativeness

- When it comes to problem-solving, we value creative solutions more than the solutions of conventional wisdom [EO6]

Dynamic capability view

Sensing

7. How should you describe the organizational ability to identify, develop, co-develop, and assess technological opportunities?

…………………………………………………………………………………………

Seizing

8. How should you describe the organizational ability of the organization to mobilize the required resources?

…………………………………………………………………………………………

<u>Step 3</u> (Silva et al., 2021)

Documentation

9. How are important decisions and activities in the supply chain reported? (Via software, excel, etc.) Why?

……………………………………………………………………………………………

Data quality

10. When this is the case, is there an easy understanding of peers? In addition, is there also poor reporting (via the software, via humans, etc.) or missing data?

……………………………………………………………………………………………

Technological infrastructure

11. What kind of technological systems are you as a supply chain department currently using?

……………………………………………………………………………………………

➔ *Those answers could result in minimizing the data latency of the organization* (Naeem et al., 2020).

Step 4 (Lima-Junior & Carpinetti, 2020)

Reliability

12. What is according to your knowledge the ability of the supply chain department to perform tasks as expected?
    a. Based on data or sentiment?

………………………………………………………………………………………………

Responsiveness

13. What is approximately the speed at which a supply chain provides products to the organization?
    a. Based on data or sentiment?

………………………………………………………………………………………………

Agility

14. How should you describe the ability of the internal supply chain to respond to external influences?
    a. Based on data or sentiment?

………………………………………………………………………………………………

Assets

15. What is your asset management strategy (e.g. the inventory reduction and in-sourcing vs. outsourcing)?
    a. Based on data or sentiment?

………………………………………………………………………………………………

Costs

16. How would you describe the costs of the current operating supply chain processes (labor costs, material costs, management and transportation costs)?
    a. Based on data or sentiment?

…………………………………………………………