# Multi-stakeholder technology acceptance: a preliminary systematic literature review on data-driven technologies for sustainability in the agri-food supply chain

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In the last decades, companies have seen a transition toward a network structure, adapting their internal focus to the external environment, thus moving from material flow improvement and cost reduction to the satisfaction of product customization. Such phenomena are even amplified when considering extended supply chains. Furthermore, the increasing relevance of external pressure belonging from sustainability challenges has led the supply chain to resort to better management of resources, among which data, through the adoption of new and emerging technologies. Despite the several benefits these technologies imply their diffusion within the supply chain has not followed the expectation. Existing literature already tried to cope with technology acceptance, defining which are the main constructs, especially from an individual perspective. What is not yet clearly defined is what happens when enlarging the boundaries to the supply chain perspective, namely considering multiple stakeholders together. Just, a few contributions tried to build a comprehensive framework. The agri-food supply chain represents one of the major supply chains when considering this scenario. Accordingly, in the last decades, this sector has seen an increase in the adoption of technologies based on data within the supply chain, giving birth to the Agriculture 4.0 paradigm. This study aims to define by means of systematic literature review whether frameworks or models exist to measure multi-stakeholder technology acceptance, and which are the drivers considered in the agri-food supply. Moreover, this paper stresses the importance of keeping updated on the set barriers that must be considered when boundaries of analysis change or evolve over time. The introduction of further actors can modify previous rules of the game and decision-making could not always be a choice for some players when dealing with multiple stakeholder's technology acceptance.

**Keywords**: Agri-food, Blockchain; Data-driven technologies; Multi-stakeholder acceptance; Technology acceptance

## I. INTRODUCTION

The agri-food industry represents one of the contexts with high potential to contribute to sustainable development, but also to be negatively impacted by related challenges. Indeed, this sector faces several sustainability challenges, many of which are complex and interconnected. Among them, there is the feeding of a growing global population, which implies a negative environmental impact (e.g., in terms of GHG emissions, water depletion, as well as soil degradation) caused by the production of more food [1]. In the environmental dimension other important issues are associated with the management of natural resources, which are critically under pressure (e.g., the consumption of water in the agricultural sector is estimated to increase by 41%) and climate change, which significantly compromises farmers' productivity [2] and increases the need to build resilient agricultural systems [3], [4]. Moreover, regarding the economic and the social dimension, the protection of the right of workers and communities, the support of rural development and food security are other relevant challenges [5]. Additionally, this sector is confronted with issues related to food waste and loss, aspects that contribute to environmental degradation and undermine efforts to reduce food security [6].

To prevent and contrast such challenges, and to support farmers as key actors of the agri-food supply chain (AFSC) in their efforts to build sustainable and resilient agricultural systems, technological innovations play a crucial role [7]. Different technological innovations have arisen over time in the agricultural domain. The most recent ones belong to the Agriculture 4.0 paradigm, which borrows key aspects of Industry 4.0 applied in agriculture [8]. This paradigm is based on the adoption of smart or data-driven technologies, which can collect and manage large quantities of data. Despite the high potential, they represent a major shift for multiple AFSC actors [9], especially farmers. As for other industries, despite the benefits of such technologies that have been widely recognised, the actual application is far from straightforward in the agri-food sector [10], with the implementation along the supply chain that has not confirmed expectations, being generally slow or failed [11].

On top of these premises, there is the need to understand the reasons hindering the diffusion. Technology acceptance is widely investigated in the current literature, anyway most of the contributions based their focus on the acceptance from an individual perspective [10], [12], mostly referring to farmers, when dealing with the agri-food sector. On the best of our knowledge, just a few contributions address this topic from a multi-stakeholder perspective. In other words, just a few papers have investigated which are the constructs or determinants that influence the acceptance of these technologies considering the influence of other actors along the AFSC or other external stakeholders (e.g., policymakers).

Hence, the main aim of this preliminary study is to understand to what extent the acceptance of data-driven technologies is presented in the literature from a multi-stakeholder perspective. This research aim is hence articulated into two research questions:

*RQ1: Which are the most investigated data-driven technologies in assessing technology acceptance?*

*RQ2: What are the factors that influence the multi-stakeholder acceptance of blockchain?*

This article is organised as follows: in Section II we report some relevant concepts and definitions to frame our study. Following, in Section III we describe the research methodology adopted. In Section IV the main results of the study are reported and in Section V they are discussed. Finally, Section VI concludes the study by highlighting future directions and limitations, as well as the theoretical and practical implications.

## II. Theoretical Background

This section aims at providing readers with the definitions of the main assumptions that frame our study. At first, we decided to apply the study to the agri-food supply chain and its stakeholders, focusing on the barriers that influence the multi-stakeholder acceptance of data-driven technologies.

### *A. Agri-food supply chain stakeholders*

The AFSC is made up of all the activities involved in the handling and transformation of agricultural products from producers/farmers to customers [13]. In other words, an AFSC includes different actors that contribute to value creation through their operations. These actors are farmers (including producers' organisations) processing companies, distributors (i.e., logistics operators and retailers), food service companies and the final consumption stage [14]. Moreover, when it comes to innovative technologies, technology providers play a crucial role in presenting to farmers and other SC actors the main advantages connected to the use of technologies, thus being further key stakeholders in the decision to adopt [3]. Furthermore, being agri-food a highly regulated industry, influenced by national and cross-national policies, other actors to be considered are governmental and regulatory bodies, as well as non-governmental organisations (NGOs) [15].

### *B. Data-driven technologies in agriculture*

Data-driven or digital technologies in agriculture are defined as those technologies that allow the "automated collection, integration, and analysis of data from the field, equipment sensors and other third-party sources" [9]. The adoption of such technologies in the AFSC is also called Agriculture 4.0. Technologies belonging to this paradigm are the Internet of Things (IoT), data analytics and big data, artificial intelligence (AI) and machine learning, geographic information system (GIS), robotics and automation, blockchain, and augmented and virtual reality [3], [9].

### *C. Multi-stakeholder Technology Acceptance*

When dealing with technology acceptance is fundamental to define the research context considered and the theoretical framework adopted not to lose an important part of the technology acceptance [12]. Here a distinction between individual/organisational technology acceptance and multi-stakeholder technology acceptance is considered. Considering the individual technology acceptance model (TAM), Davis (1989) in one of his most well-known studies, defines technology acceptance as the willingness and intention of individuals to adopt and use a particular technology. Acceptance is defined by two main constructs; the perceived ease of use and the perceived usefulness, which in turn are influenced by various psychological, social, and organizational factors [16].

Enlarging the research context to multiple stakeholder engagement in the use of technologies, technology acceptance includes in the decision-making process of a particular technology those factors associated with different stakeholders and the relationship among them [17]. Examples are suppliers and customers, developers, policymakers, and users.

## III. Research Method

The research methodology adopted is the systematic literature review (SLR). A SLR is commonly used to analyse and synthesise the prior literature [18], identify where there are gaps in current research [19], and finally provide framework/background to position new research activities [20]. The SLR performed in this research addresses the technology acceptance from a multi-stakeholder perspective, in the AFSC to identify which are the data-driven technologies mostly investigated when addressing this topic (RQ1), and which are the barriers of multi-stakeholder technology acceptance for blockchain technology (RQ2).

### A. *Data collection*

Given the aim of this study, four areas were considered in the query: technology acceptance, frameworks (i.e., the main subject of the investigation), supply chain (i.e., the scope of the investigation), and agri-food sector (i.e., the context of the investigation).

*(TITLE-ABS-KEY (((technolog*) W/2 ( acceptability OR acceptance OR adoption))) AND TITLE-ABS-KEY (("supply chain" OR "value chain" OR "supply network" OR inter-firm OR stakeholder OR inter-organisation* OR inter-company OR inter-enterprise OR b2b OR business-to-business)) AND TITLE-ABS-KEY ((model OR method* OR framework OR measur* OR assess* OR review)) AND TITLE-ABS-KEY ( (agri* OR agro* OR food OR "primary sector")))*

Papers were collected using both the Scopus and the Web of Science (WoS) databases, formulating a search string with the same structure and keywords for both databases. The search was done on March 23, 2023. Once articles have been defined and screened, 234 unique contributions are available for eligibility from title and abstract, and full-text screening.

### B. *Article selection*

Following the PRISMA framework (Figure 1), inclusion and exclusion criteria have been applied to restrict the list of papers to the ones relevant to the research objectives.

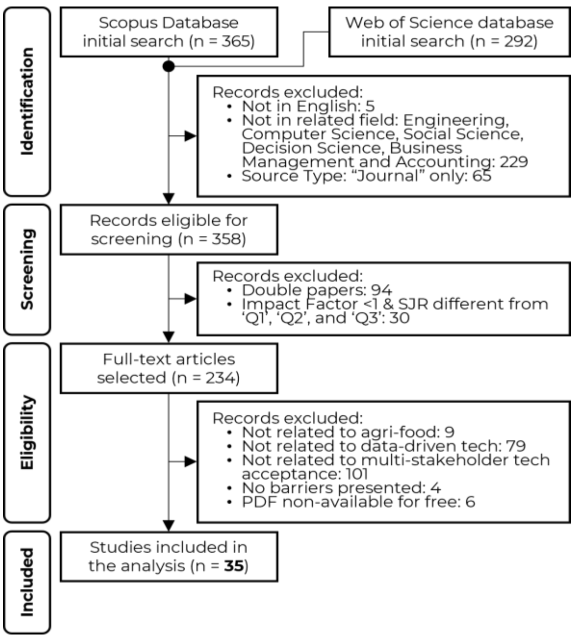


Figure 1. PRISMA framework for the selection of literature reviewed.

Before the screening phase, we exclude five papers not written in English. Moreover, we excluded articles not related to the subject areas reported in the PRISMA (Figure 1), eliminating 229 records. The same has been done for papers not published in journals, to increase the quality of results searched [21], excluding in turn other 62 articles. We concluded this phase with 358 records.

Moving to the screening of the articles, we eliminated duplicates, 94 in total, and contributions whose journal have a Scimago Journal Ranking different from "Q1", "Q2", and "Q3" and an Impact factor lower than one jointly considered, resulting in the elimination of other 30 articles. The latter criteria are intended to assure a high level of objectivity and quality of the contribution [22].

Finally, a content analysis of the title and abstract, and following on full text was performed. During this phase, 196 contributions have been excluded for various reasons: 9 not focused on agri-food, 79 not focused on data-driven technologies, 101 not related to multi-stakeholder technology acceptance, and 10 for other reasons as highlighted in Figure 1. The final pool is composed of 35 papers.

### C. *Sample descriptive analysis*

Figure 2 shows the year distribution for the contributions analysed. Multi-stakeholder data-driven technology acceptance is gaining momentum: the number of contributions published in 2022 is three times the value of papers in 2021.

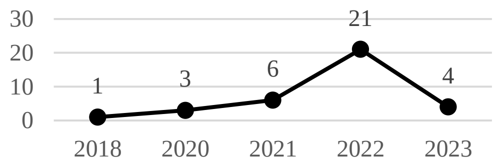


Figure 2. Year distribution.

The number of publications in 2023 is relatively small, but it is expected to rise since the search was performed at the end of March.

## IV. FINDINGS

TABLE I. DATA-DRIVEN TECHNOLOGIES FOR WHICH ACCEPTANCE BARRIERS HAVE BEEN IDENTIFIED.

| **Data-driven technologies** | **#** |
|---|---|
| Blockchain | 21 |
| Generic data-driven technologies | 7 |
| AI | 3 |
| IoT | 2 |
| Drone imagery | 1 |
| Virtual reality | 1 |
| **Totale** | **35** |

TABLE I lists the data-driven technologies that have been considered by different authors in assessing and/or determining the barriers that influence the multi-stakeholder acceptance of such technologies. The table shows that blockchain is the most investigated, representing half of the sample (21 articles), followed by generic data-driven technologies (7 articles) and AI (3 articles). Due to the prevalence of blockchain technology in the sample and its increasing relevance in the last few years, we report only results related to the factors affecting its technology acceptance.

Appendix A shows all the barriers discussed in the literature clustered in four macro categories, which are: Technology, Organisational and Supply Chain characteristics, and finally the External environment:

*Technology characteristics*: this macro area refers to barriers associated with the characteristics of the considered technology that influence the acceptance by a set of stakeholders (e.g., supply chain actors). Most of these attributes are directly connected to constructs of individual technology acceptance models, like Cost, Complexity, and Compatibility [12].

*Organisational characteristics*: this macro area refers to barriers associated with the characteristics of the organisation in which recent technologies are implemented. Examples of these attributes are the small size and the high resistance to change of the organisation, and the lack of top management support provided [23], [24]. These barriers arise when considering the influence on acceptance from a multi-stakeholder perspective.

*Supply Chain characteristics*: this macro area refers to attributes associated with the characteristics of the supply chain, such as relation dynamics within the chain like issues associated with a lack of trust and unbalanced power among stakeholders, as well as the lack of awareness concerning potential benefits and the resistance to change incurring in huge investments [24]–[26]. Furthermore, the unbalanced revenue sharing among stakeholders, and the high SC uncertainty associated with the high number of players involved among the other, represent other barriers to blockchain acceptance [27], [28].

*External environment*: this macro area refers to factors external to a single organisation and exogenous concerning the supply chain influencing the adoption. Put differently, these are factors associated with external stakeholders such as governmental institutions, NGOs, and industry associations among others. Examples of such kinds of barriers are institutional pressures [29]–[31]. Further barriers are related to the high market competition and uncertainty and the lack of support and involvement of industry associations as well as NGOs and communities [23]. Finally, even the lack of regulatory support and incentives from the government represents a barrier in fostering or hindering technology adoption decisions [8], [23], [25].

Finally, since this study focused on understanding of the adoption barriers from a multi-stakeholder perspective, it is relevant to mention the lack of information regarding the actors considered in the studies. Indeed, just 11 studies out of 21 highlight the stakeholders considered in the analysis which are affected by the barriers just reported.

## V. DISCUSSION

Considering the findings described in Section IV, some preliminary considerations are here reported.

As for RQ1, our analysis reveals that blockchain is the technology mostly investigated, followed by AI and IoT, which are often linked to the implementation of blockchain technology. Indeed, the literature highlights that blockchain underlies multiple digital technologies such as IoT and needs further resources to be implemented and integrated with existing systems [32].

As indicated in Appendix A, barriers to data-driven technology acceptance have been grouped into four macro areas or clusters. Many of the analysed frameworks in the literature are based on consolidated constructs like perceived usefulness and performance expectancy, perceived ease of use, technology complexity and compatibility, which derive from theories such as the TAM [16], the Diffusion of Innovations [12], and the Unified Theory of Acceptance and Use of Technology [33] among others. This is reflected also in more recent studies on the same topic, such as [11], [23], [34], which propose additional constructs such as organisational context, supply chain view and external view as indicated in the Technology-Organisation-Environment (TOE) framework [35].

In line with the TOE framework [35], and following with the work by [11], [23], we adopted the four categories presented in Section IV: Technology, Organisational and Supply Chain characteristics, and finally the External environment. In dealing with technology characteristics, scholars have identified many factors. Some of them are directly associated with the characteristics of the technology itself, such as the huge investments needed in its implementation, its complexity and the difficulty of the integration and interoperability within existing systems as well as its maturity [24], [25], [36], [37]. The lack of interoperability refers to the difficulty for blockchains to share and communicate with one another since written in different programming languages. For this reason, different blockchain networks result in network isolation and information asymmetry [37]. Furthermore, other factors are associated with the pros this technology can provide, like additional value proposition and comparative advantage, i.e., as defined by [11], "the degree of perception of being better than the idea or technology that an innovation replaces". Other examples within the technological group, are data and privacy protection, efficiency and transparency [8], [29], [37], [38]. A lack of these characteristics can be considered a barrier.

Moving to the organisational characteristics, scholars have identified some characteristics of single organisations that play a fundamental role in evaluating technology acceptance. One of the most cited factors is associated with the limited knowledge and competencies organisations have when dealing with blockchain [23], [24], [27], [29], [39]. Such an aspect is common also referring to supply chains different from the agri-food one, where technical expertise is a missing skill [24]. [39] highlight as a barrier the low familiarity with the implications of blockchain. In addition, [23] reports technical expertise as a critical point in the acceptance and adoption of blockchain. Indeed, a low level of knowledge and competencies, associated with blockchain, makes managers hesitant [23] and leads to postponing the implementation of the technology [40], and increases the need to educate employees and managers, generating as a consequence also additional costs [41]. Other factors that influence the decision to accept blockchain are the resistance to the change due to organisation culture and new system implementation [25], [30] and the support provided by the top management in sustaining and carrying on the new technological project [23], [28], [39], [41].

When expanding the scope to the supply chain, the multi-stakeholder logic comes into play, thus leading to a focus on dynamics among actors within the supply chain, such as lack of trust among SC actors in sharing information, and high power of some actors towards others [11]. Accordingly, scholars have started considering factors associated with the supply chain environment. Predominantly, these barriers are associated with security and privacy concerns [8], [23]–[25], [28], [36], [37], [39]. Indeed, since supply chains are exposed to fraud, hacking and access to sensitive information, the possibility to prevent these issues is considered a positive factor for adoption. Another factor influencing acceptance is the lack of trust among stakeholders along the chain in sharing sensitive information [24]–[26]. This last factor is strongly interconnected with the previous one since information sharing is crucial when considering such technologies. Moreover, another negative factor is associated with an excessive power imbalance among supply chain actors, leading in most of cases weaker actors to be aligned with buyers' intention not to lose competitiveness [24], [29]. An example is represented by the role of retailers, which usually have high bargaining power over their suppliers [29].

The fourth macro area is associated with factors belonging to the external environment, namely factors that consider also external stakeholders, such as governmental institutions, NGOs, communities, and industry associations. Among them, scholars defined factors related to market competition and uncertainty [23], [24], [34], as having a negative effect when is high. [42], highlights this barrier showing how the adoption of a new technology may lead competitors to adopt that technology whether they need it or not, increasing the competitive pressure. This is strictly correlated to one of the pressures of the institutional theory [31], i.e., the mimetic pressure. The other two are normative or prescriptive and coercive pressure. The latter is created mainly by governmental institutions that according to their behaviour influence the organisation or the supply chain [31]. Examples of barriers are the lack of regulatory support and incentives provided in implementing blockchain technology [8], [23], [25], [26], [28], [34], [37]–[39]. Instead, normative pressure is associated with expectations, values and norms and standards within the company culture [43]. The same is valid for the low involvement of industry associations in providing support and knowledge [23], [39] and NGOs and communities in understanding the potential of the technological solution [23]. Indeed, a lack of awareness and resistance, due to cultural changes, from these stakeholders in accepting the new technology is quite common [25], [26]. Different stakeholders considered are not educated or aware of the latest technologies on the market, thus postponing the adoption [44].

Finally, as highlighted in the findings, just almost 50% of the contributions considered clearly highlight which are the actors embedded in the analysis. Blockchain technology needs to be implemented all along the supply chain, thus barriers highlighted must refer to all the AFSC actors that use the technology. Having a clear understanding of the stakeholders involved in each supply chain is crucial because they can vary and have different levels of influence. This transparency facilitates informed decisions about whether to adopt certain practices or strategies. Indeed, in dealing with multiple actors, as seen before, the decision to adopt may be influenced by exogenous barriers, i.e., out of the control of the single organisation. The stakeholders mentioned in the studies are mainly supply chain actors, i.e., farmers, food processors, retailers, distributors, and consumers. Therefore, we noted that other relevant stakeholders, such as NGOs, industry organisations, and technology providers and developers, are missing.

## VI. Conclusions

### A. Future research agenda

This work represents just a first step towards the identification of the drivers and barriers that influence the implementation of blockchain when considering a multi-stakeholder perspective. In this work, we use the term acceptance as a proxy for a wider set of concepts that must be considered when dealing with this topic. Indeed, the literature highlights that different phases are considered when dealing with technology diffusion; initiation – before the adoption –, implementation – during the first interaction with the technology in a restricted context and following in the real context of the application. On top of this premise, many authors still use these two terms as synonyms. Thus, our main aim is to expand this research considering this distinction. Moreover, we derived several barriers associated with the multi-stakeholder and notably the SC scope, revealing that going in-depth into this perspective is worth a specific additional point. In particular, future research can be devoted to investigating how to solve and overcome them and whether and how such barriers affect the actors/stakeholders considered in different ways.

### B. Implications of the study

This preliminary study contributes both to the theory and the practice. It contributes to the current literature by providing an updated list of factors that influence the multi-stakeholder technology acceptance of blockchain considering recent contributions. Moreover, a peculiarity of this study is the emphasis given to governmental institutions when considering the external environment as a key barrier to blockchain acceptance. Furthermore, this has implications also for practitioners, providing company managers with a comprehensive list of barriers they should consider when approaching such recent technologies. Indeed, although benefits are in most cases clear to companies, many other factors can cause the failure in the adoption if not considered when assessing the acceptance.

### C. Limitation of the study

Finally, this study is not without limitations, which we believe could pave the way for some interesting further research. The main limitation of this study is represented by having considered in the analysis of the barriers just contributions related to blockchain technology. On these premises, we suggest researchers consider a wider range of technologies, also giving the possibility to conduct a benchmark with different data-driven solutions.

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## Appendix A. MULTI-STAKEHOLDER BLOCKCHAIN ACCEPTANCE BARRIERS

| Macro area | Reference | Macro area | Reference |
|---|---|---|---|
| **Technology** | | **Organisation** | |
| Low accessibility | [23], [32] | Small organisational size | [30] |
| High resource intensity | [26], [37] | High resistance to change | [23], [25], [28] |
| High investment cost | [8], [15], [23]–[25], [28], [29], [32], [37], [39] | Lack of top Management Support | [23], [28], [30], [34], [37], [39], [41] |
| Low maturity of the technology | [23], [30] | Lack of knowledge and training | [24], [27], [29], [30], [39], [41] |
| Lack of interoperability, integration & standardization | [8], [24], [26], [30], [32], [37], [39], [41] | **Supply Chain** | |
| High complexity of the technology | [23]–[26], [29], [30], [32], [39], [41] | Higher power of other stakeholders | [24]–[26] |
| **External environment** | | Lack of perceived traceability | [15], [38] |
| Insufficient research | [34] | Lack of trust among stakeholders | [24]–[26] |
| Lack of NGOs and communities' involvement | [23] | Lack of supply chain integration and collaboration | [23], [26], [28], [34] |
| Lack of industry involvement and support | [23], [39] | Unbalanced revenue sharing along the SC | [27] |
| Lack of rewards and incentives | [23], [32] | High number of actors involved | [23], [27], [29], [36] |
| High market competition and uncertainty | [23], [24], [29], [34] | Perceived security and privacy uncertainty | [8], [23]–[26], [36], [37], [39] |
| Institutional pressures | [29], [30] | High supply chain uncertainty | [28] |
| Lack of regulatory support and incentives from the government | [8], [23], [25], [26], [28], [34], [37]–[39] | Lack of sustainability integration | [23], [36] |