Business Information Systems Adoption in Agriculture 4.0: A Sociotechnical Exploration of Enabling Factors, Barriers, and Outcomes

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Abstract

The agricultural industry has always been considered very important economically, socially, and environmentally. In recent years, agricultural industries are beginning to use digital technologies, such as business information systems, to integrate them into their processes. Business information systems make it possible to gather information in real time, improving productivity and product safety. The adoption of information systems is still limited. The aim of the article is to explore, by combining a literature review and a survey, the enabling factors, barriers, and outcomes of business information system adoption by agricultural industries in Italy, adopting a socio-technical perspective.

Keywords

Business information systems, Digitalisation, Sociotechnical perspective

1. Introduction

The agricultural industry is a relevant sector in worldwide economies, both for the industry's size, the relevance of the production activities that guarantee food to the world population, and the sustainability impacts of such productions [1, 2]. Organisations working in the industry are adopting digital technologies supporting a transformation process of the sector towards Agriculture 4.0. These digital technologies afford organisations to collect, manage, analyse, and generate useful information for decision-making and action [3, 4]. Digital technologies like business information systems are widely used to manage operational and administrative processes. These systems allow real-time information collection to improve productivity, and product safety [5, 6]. In transitioning towards Agriculture 4.0, agriculture organisations work in contextual conditions characterised by specific organisational, economic, demographical, and technological factors that may impact digitalisation.

Despite the relevance of the industry and considering the specific contextual conditions, research on the digitalisation of agricultural industries is still limited. In this paper we intend to explore, combining a literature review and a survey, the enabling factors, barriers, and outcomes for the adoption of digital technologies by agricultural firms in Italy, adopting a socio-technical perspective. We specifically focus on business information systems, and we aim at both identifying the factors affecting the digitization of the industry and their connections. This paper aims to answer the following research question: *What is the connection between enablers, barriers, and outcomes of business information systems adoption in agriculture organisations*?

The paper is structured as follows. Section 2 contextualizes the enablers, barriers, outcomes, and context of Italian agricultural industries. Section 3 introduces the data collection and analysis

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methodology, while section 4 presents the results. Section 5 introduces the discussions and implications, and finally, Section 6 includes conclusions and future research.

2. The theoretical framework

This paper builds over two streams of literature: digitalisation in the agricultural sector and socio-technical systems theory. Each of the two streams of literature is summarised in the subsections below.

2.1. Digitalization in the agricultural industry

The digitisation of agriculture is a process in which organisations adopt modern digital technologies to pursue organisational and business benefits such as process automation, optimisation of operations and business development [7, 8]. In the literature, the digitalisation process of agricultural industry organisations is indicated with a plethora of different names [9–11]. For simplicity, in this paper, we will use the term Agriculture 4.0 to refer to the many different application areas – including both the operational and the administrative processes – of digital technologies in the agricultural industries to support and automate processes, collect data, and identify useful information in decision-making processes [7, 12, 13].

More and more technologies are being adopted in agricultural industries and among these are robots, which automate operational activities [13]. The Internet of Things allows various objects to be connected to provide relevant information to end users [2, 12]. Objects are defined as intelligent because they are connected to each other and interact through appropriate infrastructures based on local and global networks [14]. Big data help organisations in decision-making, solving internal problems and especially in planning operations [7]. Finally, business information systems are also technologies that can increase awareness of production activities, offering useful information to increase the performance of agricultural industries [4]. In Italian agricultural industries, the adoption of digital technologies is still very low. In 2021, the Agriculture 4.0 in Italy amounted to EUR 1.6 billion, but only 6% of the total area was cultivated with digital technologies [15]. According to ISTAT data, 26.1% of digitised agricultural industries are engaged in production and livestock farming, 18.4% in livestock farming, and 13.1% in agricultural activities [16].

Italian agriculture is in a renewal phase and must guarantee support for producing and distributing products to make them fast, functional, and safe [17].

2.2. Socio-technical perspective

Most of the research on Agricultural 4.0 limits the exploration on the functional and technical affordances of digital technologies on the operational processes with an agronomic perspective or limits to the assessment of the acceptance of digital technologies by farmers or employees [18–20]. For a more detailed understanding of the enablers, barriers, and outcomes of business information systems adoption, in this paper, we aim to analyse the Agriculture 4.0 from a sociotechnical point of view. A socio-technical views decomposes each setting in which people interact with digital technologies in two sides: the technical side, and the social side. These two sides are mutually interactive and needs to be addressed conjointly when approaching information systems design or evaluation.

The technical side is composed by technology and tasks, while the social side is composed by people and organisations. The two components of the social and technical side have mutual interactions and need to be addressed together for a deeper understanding of the complex dynamics developing in information systems adoption. The interactions of the sociotechnical systems adopted in this paper and summarised as proposed by Bostrom and Heinen [21], are represented in Figure 1 below.

We will use this model to classify the enabling factors, the barriers, and the results of adopting information systems, integrating the environmental aspect as an element of study and classification, and we will explore the sociotechnical interaction among these factors.

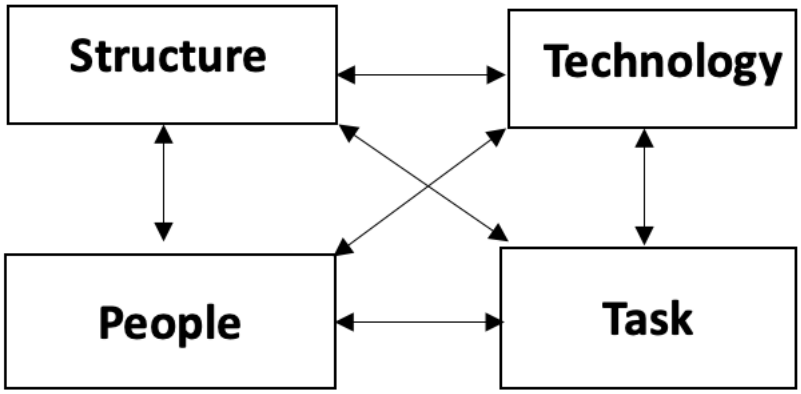

Figure 1. A socio-technical perspective framework

3. Research Design

Our research consists of two different phases: the literature review and the questionnaire. By extrapolating the enabling factors, barriers, and adoption outcomes from the literature, we designed a questionnaire to test the relevance of the factors with respect to the adoption of business information systems. The collected data are analysed to see if there is a connection between business information systems adoption and the barriers, enablers and outcomes identified in the literature.

The methodology used involves nonparametric tests, specifically the chi-square test (χ^2), which allows us to obtain information regarding the significance of observed differences between the categories that could explain the differences identified in the analysis [22].

The data used for the parametric χ^2 are obtained through a questionnaire administered to Italian agricultural industries.

3.1. Literature review

The literature analysis, carried out according to Webster and Watson [23] aims to extrapolate the enabling factors, barriers and adoption outcomes of digital technologies used in agricultural industries. The methodology, search criteria and review process results can be found in the already-published articles [24, 25]. Table 1 below shows the factors identified in the literature.

Table 1. Description factors from the literature review

Type	Name	**Code**	**Description**	**Found in**
Enabling factor / Barrier	Capabilities	CAP	Characteristics possessed by internal and external actors to contribute to the adoption of digital technologies. The skills are related to specific figures such as the farmer, the manager, the contractor, the IT expert. These figures must acquire skills through their retraining, i.e., by increasing their knowledge of digital tools. It can present itself as a barrier when there is a lack of competences on the part of stakeholders inside and outside the organisation that incentivise the adoption of digital technologies.	[4, 14, 18, 20, 26–34]

Type	Name	**Code**	**Description**	**Found in**
Enabling factor/ Barrier	Financing & Incentives	FIN	They represent a form of economic and governmental guidance that pushes agricultural industries to innovate. The absence of political incentives slows down the digitisation of agricultural industries, especially small industries, which lack sufficient liquidity to implement changes and undertake investments.	[1, 3, 4, 7, 35–37]
Enabling factor	Research & Development activities	R&D	Activities to improve production activities, based on a strategic approach, with the aim of implementing a series of practices and mechanisms to stimulate knowledge and technology transfer.	[1, 38–40]
Enabling factor /Barrier	New business Model	BUSS	Introduction of innovative and strategic business models based on the adoption of digital technologies. companies may lack innovative elements that promote the creation of new business models.	[1, 13, 14, 41–43]
Enabling factor	Collaborative relationships	COLL	joint work between figures from different organisations, based on the development of internal and external relations. By exchanging data and information with other companies, agricultural industries can achieve specific objectives, also jointly. Often, there are no prerequisites to create collaborative relationships between companies, even from different sectors to promote the adoption of technologies.	[7, 11, 14, 35, 37, 38, 42, 44–47]
Enabling factor	Dynamic and flexible environment	DYN	Identify and understand changes and opportunities affecting the performance of agricultural industries	[27, 28, 45, 46, 48–50]
Enabling factor	Same information across all levels of the organisation	INF	There must be the same level of information throughout the organisation, considering a decentralised structure	[34, 45]
Enabling factor	Disseminate results with experts in the field	DISS	Possibility of disseminating the information collected and analysed in the organisation	[13, 14, 20, 27, 29, 31, 34, 42, 48, 51–55]
Barrier	Resistance to change	RESS	It depends on dissatisfaction in the individual operational activities of the organisation, where the improvements that technologies can bring are not recognised	[4, 7, 31]
Barrier	Regulations and institutional standards	REG	Absence of rules and regulations to govern the adoption of digital technologies	[7, 26, 29, 45, 56, 57]
Barrier	Infrastructure to counter cyber attacks	INFR	Lack of tools within the organisation to counter cyber attacks	[20, 58]
Barrier	Data ownership	OWN	Data collected, analysed, and managed through technologies lack ownership due to the lack of regulations	[20, 58]
Barrier	Size of industries	SIZE	Industry size affects technology adoption, as small industries have more difficulties	[31, 59]
Barrier	Age	AGE	Age affects the adoption of digital technologies. In fact, adults are less likely to use technologies	[18]
Barrier	Technological complexity	TECH	The use of technologies is often complex due to their implementation caused by the lack of relationship between development	[7, 26, 34]
Barrier	Analytical skills for data analysis	ANALY	Lack of digital skills to digitally analyse the data collected through technologies	[1, 26, 32–34]

Type	Name	**Code**	**Description**	**Found in**
Barrier	Recognize improvements in technology adoption	REC	Inability to recognize modernity and the advantages that the adoption of technologies produces in agricultural industries	[26]
Barrier	Indicators to access how technologies affect employees work	IND	Absence of adequate tools capable of measuring human operations with respect to technologies	[40, 60]
Outcome	Production costs	PROD	The adoption of digital technologies allows to reduce all the production costs that companies use for production activities	[29, 45, 61, 62]
Outcome	New strategies useful to achieve the objectives	STRA	Adoption generates the possibility of creating new organizational and production strategies	[48]
Outcome	Decentralized organizational structure	DEC	The people who make up the organization have the same decision-making power	[37, 61]
Outcome	New production systems	NEWPRO	Production processes are becoming increasingly digitized, generating changes from an organizational and cultural point of view	[29]
Outcome	Information collected in decision-making processes to improve productivity and decision-making	INFCOL	Exploit the information gathered through digital technologies to make better decisions	[29, 34, 45]
Outcome	Dissemination of information for the identification of new production strategies	DISSINF	Take advantage of technologies to disseminate the results elaborated through the information collected	[20, 27, 34, 42, 47, 51, 53, 55]

3.2. Data collection

The questionnaire aims to investigate the adoption of business information systems in agricultural industries, seeking to investigate barriers, enabling factors, and adoption outcomes. Question constructs are derived from items identified in the literature review, often extrapolated from previous studies that tested similar contexts [28, 33, 63]. The questions that make up the questionnaire are mainly implemented with Likert scales of 1 to 5 points (1 - Strongly disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, 5 - Strongly agree). We submitted the questionnaire using an online database, which includes information from 3,286 Italian companies in the agricultural industry and their respective email addresses.

Before sending the questionnaire to the full database, we subjected the questionnaire to two stages of revisions. In the first stage, with the help of experts in the field, we checked for functionality and correctness. In the second stage, we tested the pilot questionnaire with a sample of 193 companies belonging to the Lazio Region, which allowed us to observe and verify the correct functionality and understanding of the questions and the obtaining of feedback for improvement.

After the pilot test we improved the questionnaire due to the feedback obtained from the pilot questionnaire participants. The questionnaire administration started in April 2023, with Google Moduli, and is still ongoing, and to date, we have obtained 211 responses, with a response rate of 6,7%.

3.3. Chi-squared test

Through the χ^2, we want to test the existence of a connection between each group of the enabling factors, barriers, and outcomes and the adoption of business information systems. The χ^2 can measure the association between two category variables by considering the following hypotheses:

- H0 = 0 (Independence between two variables)
- H1 ≠ 0 (Dependence between variables)

The factors analysed in the test are derived from the literature. We summarise the enabling factors, barriers, and outcomes in the following tables 2.

Table 2. Factors tested with role (E: enabling, B: barrier, O: outcome)

Code	People	Task	Structure	Technology	Context
CAP	**E B**				
FIN		**E B**			
R&D		**E**			
BUSS			**E B**		
COLL	**EB**				**E**
DYN					**E**
INF				**E**	
DISS				**E**	
RESS		**B**			
REG		**B**			
INFR				**B**	
OWN				**B**	
SIZE			**B**		
AGE	**B**				
TECH					
ANALY	**B**				
RED	**B**				
IND	**B**				
PROD		**O**			
STRA			**O**		
DEC			**O**		
NEWPROD		**O**			
DISSINF				**O**	

4. Findings

4.1. Data analysis

Table 5 below summarises the individual descriptive characteristics of the respondent, while Table 6 describes the industry's size.

Table 3. Summary of demographic characteristics

Demographic characteristics		Frequency	Percentile
Gender	Male	43	81%
	Female	10	19%
	Total	53	100%
Age	18-30 years	10	19%
	31-40 years	10	19%
	41-50 years	19	36%
	51-60years	10	19%
	>60 years	4	7%
	Total	171	100%
Qualification	Middle certificate	1	2%
	Higher Diploma	17	32%
	Bachelor's degree	7	13%
	Master's degree	22	42%
	PhD/Master	6	11%
	Total	171	100%

Table 4. Summary of Industry Characteristics

Industry characteristics		Frequency	Percentile
Turnover	≤ 200.000€	23	44%
	200.001-700.000€	14	27%
	700.001-1.800.000€	5	9%
	>1.800.001€	11	20%
	Total	171	100%
Size	0-19 employees	41	78%
	20-49 employees	6	11%
	50-249 employees	5	10%
	250-499 employees	0	0%
	>500 employees	1	2%
	Total	171	100%
Production	Agricultural	41	77%
	Livestock	1	2%
	Either	11	21%
	Total	171	100%
Experience	<5 years	3	6%
	5-10 years	14	26%
	>10 years	36	68%
	Total	171	100%

The results show that the respondents are mainly men (81% of the sample) with an age range 41-50 years of age (36% of the sample) and with a master's degree (42% of the sample). The industries have a turnover of ≤ € 200,000 (44% of the sample) and a size of 0-19 employees (78% of the sample). This observation is compatible with the general characteristics of the Italian context. Finally, respondents state that they have more than ten years of experience (68% of the sample), and agricultural production characterizes the largest number of industries involved in the study (78%).

4.2. Identify the connection between enabling factors, barriers, and outcomes with digital technologies

To answer our research question, we conducted the χ^2 test. Below, in Tables 7, 8, and 9, we reported the value of each test χ^2.

In the following Tables, xsquared represents the value of test χ^2 obtained. Df indicates the degrees of freedom, p-value means the probability of the null hypothesis, and finally, supported shows, based on the results obtained, whether the factors have connections with the digital technologies analysed.

Table 5. Chi-square test of management information systems enabling factors

Code	xsquared	df	p-value	Supported
Cap_ff	18,792	4	0,0008633	X
Fin_f	7,4717	4	0,113	
R&D_f	9,3585	4	0,05274	X
Buss_ff	5,3962	4	0,249	
Coll_f	5,0189	4	0,2854	
Dyn	13,321	4	0,00981	X
Inf	14,075	4	0,007058	X
Dissf	4,4528	4	0,3482	

Table 6. Chi-square test of . Valmanagement information systems barriers

Code	xsquared	df	p-value	Supported
Fin_b	3,1321	4	0,536	
Ress	11,623	4	0,02039	X
Reg	16,34	4	0,002596	X
Infr	18,981	4	0,0007927	X
Own	16,151	4	0,0002823	X
Cap_b	18,792	4	0,0008633	X
Coll_b	21,057	4	0,0003086	X
Buss_b	21,811	4	0,0002185	X
Size	0,86792	4	0,9291	
Age	18,415	4	0,001024	X
Tech	12,943	4	0,01156	X
Analy	18,604	4	0,0009401	X
Rec	28,038	4	1,226e-05	X
Ind	25,019	4	4,987e05	X

Table 7. Chi-square test of business management information systems outcome

Code	xsquared	df	p-value	Supported
Prod	36,34	4	2,464e07	X
Stra	18,226	4	0,001114	X
Dec	22	4	0,0002004	X
Newpro	17,66	4	0,001438	X
Infcol	13,509	4	0,009037	X
Dissinf	23,321	4	0,0001092	X

5. Discussion

The article we have proposed constitutes the initial step of a research project which aims to analyse the adoption of business information systems in Italian agricultural industries [49, 60, 64]. Through the questionnaire, we tried to identify whether there are links among the barriers, enabling factors, and results related to the adoption of business information systems in agricultural organisations.

Through χ^2 analyses, we identified relationships between the adoption of business information systems with barriers, enabling factors, and adoption outcomes. The results show that not all factors identified in the literature have links with business information systems. The model proposed below (Figure 2) includes, from a socio-technical perspective, the ranking of factors that show links because of the analysis conducted.

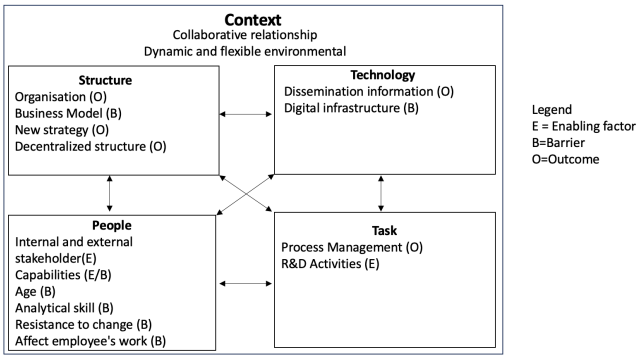

Figure 2. Results of analysis

The proposed new model is very similar to the model in section 2. The factors removed are funding and incentives, present in both barriers and enablers and size of industries. The analysis of $\chi 2$ shows that in both cases the adoption of business information systems is not related to the funding that the State grants for the adoption of technologies. Industries decide to adopt business information system in the presence or absence of incentives granted by the state. The companies autonomously decide to adopt business information systems, analyzing the actual usefulness but above all the intention to implement a digitization process which will lead to changes in the organization.

As regards the enabling factors, in addition to *financing and incentives*, *new business models*, *collaboration relationships* and *dissemination of results with experts in the field* are not linked to the adoption of business information systems. The *new business models* depend on the organization that decides to undertake a digitization process, characterized by the introduction of digital technologies such as business information systems [39]. The absence of a link between the adoption of business information systems and new business models derives from the possibility of creating new models even without the need to integrate digital technologies into processes. Having the skills and having an active environment open to change encourages companies to create and develop new businesses [42].

As far as *collaboration relationships* are concerned, the adopting depends on the willingness of companies to adopt digital technologies even without relationships with companies inside and outside the sector. Collaborative relationships characterize the organizational context rather than the socio-technical perspective. On the other hand, new business models and collaborative relationships, from the point of view of barriers, have links with adopting business information systems.

From a socio-technical perspective, the adoption of business information systems can be limited due to the absence of collaboration between companies lacking in the organization of relations with companies and with external stakeholders, which favor the adoption of business information systems, solving problems such as those related to lack of skills [53].

As far as new business models are concerned, organizations are incentivized to maintain traditional rather than innovative production models. Production practices are poorly digitized and less and less automated [47].

As far as barriers are concerned, company size is a factor unrelated to the adopting of business information systems. Agricultural industries may decide to adopt digital technologies regardless of their size as they may have the necessary elements, such as the skills and the willingness to innovate and develop new, increasingly digital, business models [33].

Finally, as far as adoption results are concerned, we see they all have links with adopting information systems.

The research has theoretical and practical implications.

Regarding the theoretical implications, the research, being at an early stage, does not fully consider the socio-technical perspective. Indeed, the studies conducted to identify factors and the

existence of links between business information systems adoption and enabling factors, barriers and adoption outcomes are not analyzed and described from a socio-technical perspective.

For this reason, this article is a starting point in need of additions towards realizing further, even more complex analyses that consider technology adoption and a detailed description of factors, barriers, and adoption outcomes from a socio-technical perspective.

According to a practical implication, the adoption of information systems depends on several factors, which may stimulate or limit adoption or present themselves as results. In the organization, Agriculture 4.0 requires a change at the operational, management, but also administrative level. Several studies can be found in the literature analyzing the digitization process and the changes required [7, 13, 36]. However, the organization does not always have a flexible and change-oriented environment and often, the presence of stakeholder resistance to change reduces the intention towards digitization.

6. Conclusion

The research explores, considering agriculture 4.0, the link between the enablers, barriers, results, and the adoption of business information systems.

Based on the analysis of χ^2, we note that adopting business information systems depends on different factors that influence the organization. In some cases, they can appear both as an enabling factor and a barrier. Since data collection is still in progress, the results obtained could change, with the possibility of getting additional information, which would allow for more integration of the analysis through a socio-technical vision.

The organization must increasingly integrate business information systems with its operations and activities, having greater awareness and adequate knowledge to use them.

The article has limitations. Currently, the study only considers a test between a factor and business information systems adoption but does not explore possible combinations and co-occurrences between factors and business information systems adoption, which will be done in subsequent studies.

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