Current and Future Opportunities of Digital Transformation in the Agrifood Sector

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Abstract. Digital transformation is a process determined by new technologies that not only enhances traditional processes of innovation and development but creates new forms of innovation in every segment of society. It in the agro-food sector plays a crucial role in counteracting the critical factors of globalization and the growing environmental impact. In Italy, the growth potential of the "Agriculture 4.0" and "Farming 4.0" solutions market is very high, but the adoption of related technological innovations is still reduced. Italian companies are increasingly aware of the opportunities offered by the 4.0 paradigm, but there are still cultural and technological limitations for a full development of the phenomenon. The research aims to provide a first contribution to the perception that Italian agricultural operators have about the opportunities and limits of the adoption of smart agrifood. The first results, obtained from a multicriteria analysis approach, will be presented to define possible future scenarios deriving from the implementation of Digital transformation.

Keywords: smart agrifood; Internet of Things; Agriculture 4.0; Farming 4.0; multicriteria analysis.

1 Introduction

Digital transformation is a process that influences every aspect of human society. It is a transformation determined by new technologies that not only enhances traditional processes of innovation and development, but creates new forms of innovation characterized by clear and rapid changes, and affects every segment of society, such as the economy, communication tools, government, information, art, medicine and science (Weiss et al., 2005; Zheng et al., 2016). From the economic point of view, digital transformation can be defined as the process that redesigns and makes the company's overall offer more competitive, through the transformation of production processes, analysis and listening to market needs using digital technologies (McAfee, 2014).

The definition highlights the importance of the innovative aspect of Digital Transformation linked to the originality of the transformation. In order to understand

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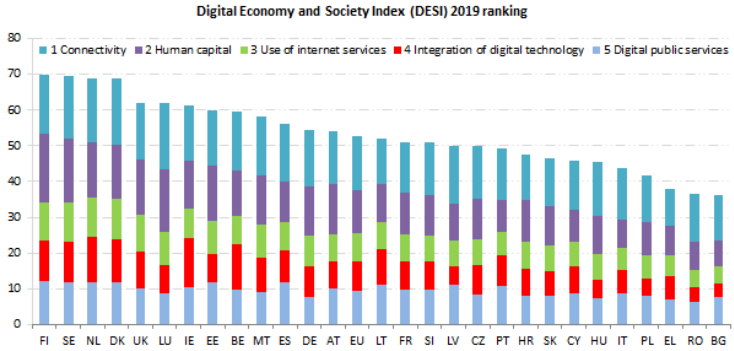
the Digital Transformation process, it is necessary to analyze some enabling technologies, distinct in product-service and process innovations, which assume a strategic economic significance (Janvier, 2012). In particular, it is useful to give some hints on the key concepts: Internet of Things and Big Data.

"Internet of Things" (IoT) is a neologism referring to the extension of the Internet to the world of objects and concrete places, equipped with a more or less permanent connection to the Internet as well as sensors and other devices capable of monitoring and recording people's actions and habits. The connection of these objects (IoT devices) to the Internet allows the exchange, storage, sharing, processing of huge flows of information and data.

The term "Big Data" refers to the set of data with dimensions that go beyond the capacity of commonly used software tools. Digital technologies have multiplied the available data at an exponential rate, generated by sensors, social media, transactions, smartphones and other sources. Big Data" can represent a real asset for companies, whose potential can only be expressed through their intelligent use.

The digital transformation is proceeding at an increasing pace but in a diversified manner in the individual countries (Spielman, 2006). As far as the European Union is concerned, a picture of the situation of this phenomenon can be taken from the Digital Economy and Society Index (DESI). The DESI is a composite index that summarizes relevant indicators on Europe's digital performance and tracks the progress of EU Member States in digital competitiveness. The five dimensions of the DESI are: connectivity; human capital; use of internet; integration of digital technology; digital public services. As reported in Fig. 1, Italy still has a large gap to catch up, in fact, it is in 24th place in the ranking of the 28 EU Member States. Instead, in the first places are Finland, Sweden, Holland, Denmark.



Source: DESI, 2019

Fig. 1. Digital Economy and Society Index in European Union States (2019 ranking)

In general, in Italy companies are slow to understand the potential of the network: 40% of entrepreneurs declare that it is not useful to their activity. Many entrepreneurs are still not aware of the potential offered by the network for the promotion of products, for business turnover thanks to e-commerce and interaction with customers with social media (Cagnina et al., 2018).

The data for the last few years shows a slow improvement for Italy, but the distance from the European average is still evident, an alarming situation especially if we consider the growing importance of the digital economy, especially in the near future (OECD, 2019).

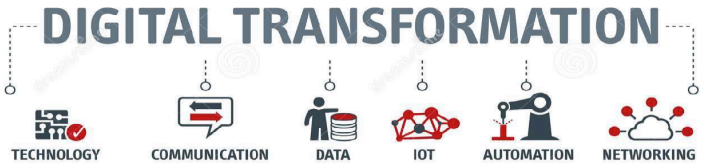
2 Digital transformation in the Italian agrifood system

Digital transformation in the agrifood sector plays a crucial role in our society and to counteract the critical factors of globalization and the growing environmental impact (Weis, 2005; Ge et al, 2016). In Italy, the market growth potential of "Agricoltura 4.0" and "Farming 4.0" solutions is very high, but the adoption of technologies such as robots and precision farming sensors is still reduced.

In this context, "Agricultura 4.0" solutions are integrated with "Farming 4.0" solutions, according to an approach based on the integration of various ICT/geo-space technologies (Lee et al., 2017). That is, reliable remote monitoring is possible through space-time and spectral measurements, able to monitor the phenomena at the level of individual sites from various altimetric positions.

Similarly, the Blockchain technology applied to the agrifood supply chain makes it possible to guarantee a transparent, safe and shared environment for the traceability of the components and processing processes of agrifood products offered to the consumer (Kempe et al., 2017; Krishnan et al., 2012; Scuderi et al., 2018; Tapscott, 2016). For example, the Italian Food chain makes it possible to securely (and decentrally) collect, record, analyze, validate and certify data, information and documentation at every stage of the supply chain, through the open functionalities of blockchain, through the use of the "smart contract" concept (Scuderi et al., 2019; Timpanaro et al., 2018).

In summary, systems and technologies such as GIS / geo-spatial infrastructures, fixed and mobile ultra-broadband networks, Internet of Things, Artificial Intelligence, Blockchain, Augmented and Virtual Reality, etc. are available. These make possible the provision of digital services through intelligent platforms for "green & sustainable development" applications (Precision Farming / Farming 4.0, food chain tracking, e-health, etc.) (Abeyratne et al., 2016), using case by case the most appropriate combinations of these technologies. With the availability of advanced skills and technologies available "as a service" in the Cloud, and the support of researchers and experts in the various "verticals", it is possible to implement initiatives (market-driven) for the provision of "digitized" value-added services in the field of "green" development (Chen et al., 2016). It will be necessary to guarantee users the transparency of the process, i.e. the mix of advanced technologies used to generate the value of the chain (fig. 2).



Source: FAO, 2019.

Fig. 2. The components of digital transformation

There is enormous potential for growth and market development in the agrifood sector. In fact, only 2% of the Italian agricultural area uses robots and precision farming sensors, which are not uniformly distributed in the various regions of the country (De Molli et al., 2017; De Paulis, 2015). Digital" agriculture (ICT-assisted) varies between minus 1 and 4-5%, compared to 40-70% in China, Israel and the USA. The most frequent solutions are systems that can be used transversally in several agricultural sectors, followed by those aimed at the cereal, fruit and vegetable and wine sectors. The focus on the Internet of farming is growing, albeit very slowly (Osservatori.net, 2019).

The research aims to provide a first contribution to the perception that Italian agricultural operators have about the opportunities and limits of the adoption of smart agrifood. The first results, obtained from a multicriteria analysis approach, will be presented to define possible future scenarios deriving from the implementation of Digital transformation.

3 Methodology

The present study analyzes the digital transformation to identify new approaches and opportunities in the agrifood sector that can be used to develop guidelines, to enhance production, consumer protection, and to analyze the value chain.

The proposed approach is based on integrating participatory planning and the novel approach to imprecise assessment and decision environments as a possible methodological structure to acquire and evaluate the “complex” information collected on possible alternative scenarios in relation to digital transformation (Munaretto et al., 2014; Scuderi et al,.2016).

The aim is to develop a methodological structure using suitable tools to acquire first, and process second, qualitative and quantitative information concerning the possible alternative scenarios of the problem under study. The opinions were collected through specific focus groups with local stakeholders, operators, consumers, and producers interested in the issue in question.

The proposed model is based on:

- the individualization of stakeholders involved (30 questionnaires);
- the definition of the alternative scenarios (definition of the three hypotheses of scenario: Farm, Chain and Consumers.

The model used focus groups as a social research methodology, aiming to acquire

information on the opinions of stakeholders regarding a variety of scenarios for future development (Scuderi et al.,2016). The matrices of impact and equity constitute the basis for the use of the discrete multicriteria evaluation NAIADE model (Munda, 2006), which is able to manage qualitative and quantitative data in order to evaluate the measures of intervention. This instrument supports the classification of the alternative scenarios proposed on the basis of determined decisional criteria and considerations of possible "alliances" and "conflicts" between the groups of stakeholders for the proposed scenarios, thus measuring their acceptability (Sturiale et al., 2018).

The objective of this study is to analyze the principal priorities, using as its methodology the model of digital transformation in the agrifood sector. The evaluation through the focus groups was divided into three phases, referring in this specific case to the potential repercussions.

The questionnaire used for the interviews was designed to explore the perception of traceability issues in the citrus-supply-chain context and to evaluate the real needs of actors in the supply chain. It comprised 10 questions aiming to collect information and opinions useful for the research related to three hypotheses proposed (Farm, Chain and Consumers):

Scenario Farm: application of digital transformation for the valorization of the agricultural productions on the basis of the quality of the product.

Scenario Chain: application of digital transformation in order to gain control information and prices along the chain.

Scenario Consumer: application of the digital transformation is aimed at protecting the health of the consumer.

The input of the NAIADE method is constituted by the impact matrix (criteria/alternative matrix), including scores that can take the following forms: crisp numbers; stochastic elements; fuzzy elements; and linguistic elements (such as "very poor", "poor", "good", "very good", and "excellent"). To compare alternative scenarios, the concept of distance is introduced. In the presence of crisp numbers, the distance between two alternative scenarios with respect to a given evaluation criterion is calculated by subtracting the respective crisp numbers.

The classification of alternative scenarios is based on data from the impact matrix, used for:

- comparison of each single pair of alternatives for all the evaluation criteria considered;
- calculation of a credibility index for each of the aforementioned comparisons that measures the credibility of one preference relation, e.g. alternative scenario (a) is better / worse, etc. than alternative scenario (b) (preference relationships were used);
- aggregation of the credibility indices produced during the previous stage leading to a preference intensity index [μ * (a, b)] of an alternative (a) with respect to another (b) for all the evaluation criteria, associated the concept of entropy [H * (a, b)] as an indication of the variation in the credibility indices; and classification of alternative scenarios on the basis of previous information.

The final classification of the alternatives is the result (intersection) of two different classifications: the classification Φ + (a) (based on the "best" and "decidedly better" preference relationships); and the classification Φ – (b) (based on the "worst" and "decidedly worse" preference relationships).

In relation to the objective of the present study, the analysis will be applied to the main priorities, for the assessment of the scenario that benefits most from digital transformation implementation in the agrifood sector.

4 Results and discussion

The results of the present study provide a further multidisciplinary contribution to research on the management of digital transformation. Specifically, the analysis was conducted to address the research question:

What are the opportunities that Digital transformation for the agrifood sector?

The evaluation criteria were used is technology, communication, data, Internet of things, automation and networking. These criteria were defined on the basis of the purpose and objectives of the evaluation of the analyzed case, which can be considered representative of agri-food sector.

The scenario Chain was revealed to be the best option for sharing, closely followed by scenario Farm and scenario Consumer, but all three hypotheses had positive evaluations (tab. 1).

Table 1. Objectives and evaluation criteria of digital transformation for agrifood sector.

Evaluation criteria	Scenario FARM "P"	Scenario CONSUMER "C"	Scenario CHAIN "M"
Technology	Excellent	Good	Excellent
Communication	Very good	Excellent	Excellent
Data	Good	Excellent	Very good
Internet of things (IOT)	Poor	Very good	Excellent
Automation	Very good	Good	Very good
Networking	Good	Exellent	Very good

Source: our elaborations

This provided the views of interested parties on the three suggested hypotheses. The selection of interested parties was based on their potential to assess the major advantages for agrifood sector. A total of eight six groups of stakeholders were involved: producers; trade associations; dealers; consumer associations; institutions and scientific associations. It is important to underline that the opinions of the interested parties in the NAIADE model can only be of a qualitative type, i.e. linguistic expressions: bad; poor; medium; good; very good; and excellent. The results show that a large number of stakeholders and groups of selected operators agreed with the assessment of the three hypotheses. The results of the multi-criteria analysis revealed that the scenario Chain was the predominant hypothesis, closely followed by scenario Chain, while scenario Consumer acquired only a lower rating (Tab. 2).

Table 2. Classification of the scenarios at the highest consensus level.

	Groups and stakeholders	Scenario FARM "P"	Scenario CONSUMER "C"	Scenario CHAIN "M"
A1	**Producers**	0,7387	0,6311	0,8470
A2	**Trade associations**	0,6732	0,7334	0,6213
A3	**Dealers**	0,5764	0,6218	0,6138
A4	**Consumer associations**	0,5216	0,6392	0,8723
A5	**Institutions**	0,6283	0,5357	0,8231
A6	**Scientific association**	0,8329	0,7342	0,6379

Source: our elaborations

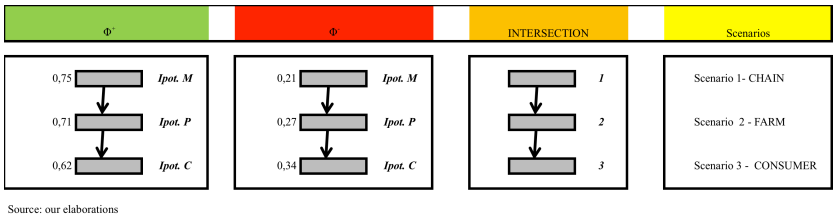
The results obtained through the analysis of the single answers were used to examine possible alliances or conflicts between the opinions of the interested parties regarding the decision on which hypothesis to adopt. The results in Tab. 3 show that a large number of interested parties, in addition to agreeing on the classification of the different hypotheses to be applied, agreed with scenario Chain, while noting that there were also significant consequences for the Farm and Consumer scenarios.

Table 3. Consensus and related prioritization of scenarios.

	Consent levels			
Scenario classification	0,7525	0,7603	0,7323	0,7863
	M	M	C	M
	P	P	M	P
	C	C	P	C
Groups of "alliances" at each level of consensus	All groups	All groups except A3	All groups except A3 - A4	All groups except A2 e A6

Source: our elaborations

The results include different perspectives of digital transformation, the different groups involved the perception and acceptability of the proposed alternatives, which can lead to improving strategic decisions and creating innovative ideas and new solutions to enhance and protect, based on the possibilities offered by these participatory processes (Fig. 3).



Source: our elaborations

Fig. 3. Classification of alternative hypotheses and multicriteria assessment

The results obtained from this model, developed through the integration of a participatory tool and a multicriteria analysis, become strategic for investment choices in the agrifood system, particularly in relation to the current situation in which the supply chain, the farm and the consumer try to define their role through digital transformation.

5 Conclusion

The Italian agrifood sector has begun to understand that digital innovation is a strategic lever, able to guarantee greater competitiveness to the entire supply chain, from production in the field to food distribution, passing through processing (Sturiale et al., 2016).

Digital transformation is fundamental to improve the competitiveness of the agri-food sector not only for economic needs but also for social and environmental ones (Scuderi et al., 2019). The remuneration of all phases of the agro-food chain includes correct economic and contractual relations between all actors: agricultural producers, processing and distribution industry; greater cooperation and transparency, adoption of product and process innovations. This condition is essential to allow the improvement of quality, social and environmental standards, also in the logic of improving the efficiency of production, innovation and marketing processes. The success of agricultural enterprises increasingly depends on the ability to collect and enhance the large amount of data that will be generated, especially to achieve cost control and increase the quality of production. It should be noted, however, that there is still little clarity among those involved in the sector on how to exploit these opportunities. It is necessary to invest in the creation of skills, in a sector characterized by a level of 'corporate' culture and operational processes based more on the transfer of generational skills and knowledge than on innovation and optimization of production processes.

The food economy should therefore constitute a resource capable of responding to the most urgent and immediate needs of the planet, regulating the production of this primary resource, encouraging innovative and environmentally friendly production techniques, but above all ensuring a fair distribution of the resources produced through the aid of digital transformation.

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