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How to increase the sustainability of the agri-food supply chain through innovations in 4.0 perspective: a first case study analysis

Stefano Saetta^a, Valentina Caldarelli^{a*}

^a*Department of Engineering, Università degli Studi di Perugia, Via Goffredo Duranti 93, 06125 Perugia, Italy*

* Corresponding author. E-mail address: valentina.caldarelli@unipg.it

Abstract

The paper aims to analyze the agri-food supply chains to identify possible fields of intervention that improve logistics and the management of the entire supply chains by introducing technologies and devices in the 4.0 perspective. The agri-food sector includes the set of activities aimed at the production, processing and distribution of food products. In particular, the paper identifies technological innovations that can improve distribution logistics and management of the entire supply chains. The paper presents a first survey of companies in the agri-food sector and a preliminary assessment of possible solutions for identifying logistic improvement measured through specific parameters.

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Keywords: agrifood logistics, supply chain management, industry 4.0

1. Introduction

There is an increasing interest in the environmental, social and economic effects of the agri-food supply chain caused by the production and consumption of food. The agri-food supply chain concerns the farming goods from production level to final consumers. A typical food supply chain consists of several phases: procurement of raw materials, production, processing and packaging, storage, wholesale distribution and retail redistribution for consumers [1].

The agri-food supply chain can achieve sustainable growth by focusing on the best management practices of the entire supply chain and on improving social and environmental conditions ([2], [3], [4]). Interesting aspects that can make this supply chain more sustainable are the involvement of smaller companies, stricter rules for control, quality and safety [5], greater industrialization of processes and improvement of the entire management [6]. The aspects just listed indicate the need to act not only on how food is produced but on the entire supply chain that includes food processing, packaging, distribution and consumption ([7], [8]).

There is also a growing use of new technologies, such as the internet of things (IoT), that have a significant impact on supply chain sustainability [9]. IoT support collection and sharing of information in real time: the communication, cooperation and coordination between the components of the supply chain are improved [10]. Moreover, IoT and the use of sensor technologies reduce the demand-supply gap and improve the food quality and security ([11], [12]). In recent years, the blockchain technology is also developing. A blockchain is a distributed database of records in the form of encrypted blocks of all transactions or digital events that have been executed and shared among participating parties and can be verified at any time in the future [13]. Even if the blockchain technology was born in the Bitcoin – a peer-to-peer electronic cash system [14], it is applied in different sectors as finance [15], smart city [16], healthcare [17] and agri-food [18]. The benefits that the blockchain five to the supply chain are several: information continuity, traceability, information security, link between information flow and material flow [19,20]. All the members of the agri-food supply chain have benefits from the blockchain based systems. The

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food producers ensure the quality of their supplies. In the retailer side it would be easier to trace the damaged food product without checking the whole supplies. The consumers know what quality food they are consuming at the end [20].

[21] reveal that the environmental aspect of the sustainability received more attention in the literature (92%, 77 out of 84 papers), followed by economic aspect (54%, 46 out of 84 papers) and social (51%, 43 out of 84 papers) dimensions. The social sustainability in the agri-food supply chain is facilitated by short supply chain and by regional food hub, influencing the communication and relations ([22], [23], [24]). The economic sustainability is achieved reducing the overall costs and minimizing the transportation costs [25]. This aspect has impact on the total carbon emissions, water footprint and job created ([26], [27]).

Some logistics best practices for the improving of the efficiency and effectiveness of the agri-food supply chain are provided in [28]: transportation, warehousing and inventory management are the logistics fields where it is most possible to obtain improvements.

The paper aims to investigate the technological innovations that can improve the entire supply chain through interviews with companies operating in the agri-food sector. The first results presented could be a guide for researchers and professionals in the sector.

The remaining of the paper is organized as follows: Section 2 is dedicated to the depiction of the methodology used. In Section 3 results are presented and discussed. Section 4 contains the conclusions.

2. Methodology

The research question that the work poses is:

- What innovations can improve the sustainability of the food supply chain?

The research approach (see Fig. 1) is therefore based on the identification of these technological innovations through the preparation and subsequent submission of surveys and direct interviews with companies in the agri-food sector. Finally, a first results analysis is made.

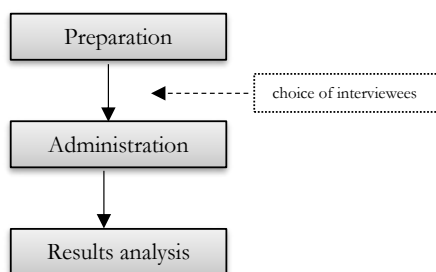


Fig. 1. Research approach

2.1. Preparation and choice of interviewees

The first step of the research approach is the preparation of the survey questions. The focus is on some particular business aspects in order to obtain interesting feedback to respond to the RQ. The macro-categories on which the questionnaire was drawn up are:

- Plant crossing times
- Vehicles and types of cargo
- Level of production satisfaction
- Stocks and rotation indexes

The collection of data relating to the crossing times of the plant concerns the collection of information on customer and plant lead times, analyzing the processing, tooling, handling, inspection and waiting times. The part of the survey on vehicles collects information on the number and size of vehicles, as well as the routes of each vehicle. Concerning the level of production satisfaction, the survey focuses on the measurement of readiness, punctuality, availability and accuracy indicators. Specifically, data are collected on delivery delays, errors in production and shipping. Finally, the data on stocks refers the different types of raw materials and finished products and their relative indexes of rotation.

The choice of the companies object of the surveys is made starting from an analysis of the Umbrian territory and focusing on medium-large companies operating in the agri-food industry sector.

3. Results

The surveys were submitted to five companies in the agri-food sector. The choice of these five companies is derived from their size and their market areas. Furthermore, the willingness of the companies themselves to join an overall supply chain to increase their economic and social sustainability, was considered important in the choice of companies. The five companies interviewed operate in the supply chain of milk, fruit and vegetable products and cereals.

The data that emerged from the administration of the questionnaires were interesting to identify the technological innovations that make the supply chain of the food sector more sustainable. However, being in the first steps of the research, not many numerical data to analyze are collected but the surveys provide a direct comparison with the business realities towards those technological innovations that can improve the supply chain.

Interesting analyzes of control times and waiting times in one of the five companies, highlighted the possibility of reducing them by introducing the use of metal detectors. Beyond this possible technological innovation, also comparing the answers on the crossing times with those regarding the level of production satisfaction, it is clear there is no need for intervention in the production or assembly lines of the five industries interviewed. In fact, the surveys on the level of production satisfaction did not reveal any areas for improvement.

Therefore, considering the answers for the crossing times and the level of production satisfaction, the need to introduce technological innovations within the warehouse emerged.

This same requirement is also evident analyzing the data collected on stocks. In particular, the improvement in warehouse management can take place on two fronts. On one hand a system already known and used for some time, but which in some agri-food companies has not yet been used: an intelligent labeling system that allows a more correct identification of the finished product as well as the possibility of having a series of information available also to the final consumer. On the other hand, there is the possibility of having a more efficient communication between the commercial part that in some companies is outside the company and the warehouse management part. Improving this communication, with the possibility of having an “online warehouse”, a more efficient control of stocks and an increase in the level of satisfaction of the end customer are obtainable.

Finally, analyzing the data on vehicles and the system of transportation, the five companies highlight the need of introducing hubs, i.e. load consolidation centers. The objectives of these freight transport initiatives are the avoidance of poorly loaded goods vehicles reducing goods vehicle traffic thanks to the transshipment and the consolidation of goods. Moreover, the load consolidation centres intend to reduce greenhouse gas emissions improving local air pollution within urban areas [29]. Considering the type of products that would be present inside the hub, these companies could create a food hub that is “a centrally located facility with a business management structure facilitating the aggregation, storage, processing, distribution, and/or marketing of food products” [30].

The inclusion in the supply chain of a hub would bring several advantages: local economies would be supported by providing market opportunities for small-scale producers and treating them as valued business partners, rather than interchangeable suppliers [30].

The introduction of the hub allows to have a single shared point of departure and arrival, whose position must be subsequently evaluated. The hub is in fact a facility shared by several companies that can obtain economic benefits for the distribution of the finished product. Load consolidation, vehicles loaded in a more effective and efficient way, together with route optimization, lead to a reduction in the kilometers traveled, increasing not only economic but also environmental sustainability. The benefits obtained from route optimization and the assessment of environmental benefits are present in [31] and in [32].

Table 1 shows the results of the survey highlighting for each topic the possible technological innovations, listed in Table 2.

Table 1. Macro-categories and technological innovation. Results from surveys.

	Technological innovations	
	Devices	Infrastructures
Plant crossing times	+	
Vehicles and types of cargo		+
Level of production satisfaction	+	
Stocks and rotation indexes	+	

Table 2. Technological innovation

	Technological innovations	
	Devices	Infrastructures
Metal detectors		Hub
Labeling		
Online warehouse		

As already mentioned above, the analysis is at the first steps and the results are relative only to the identification of technological innovations. It will therefore need to carry out a more in-depth analysis by detecting the performance of each company at present, comparing them with the same performance measured after the introduction of technological innovations.

4. Conclusions

The paper aims to analyze the agri-food supply chains to identify possible fields of intervention that improve logistics and the management of the entire supply chains by introducing technologies and devices in the 4.0 perspective. Through the administration of surveys to different companies in the agri-food sector, a preliminary assessment of possible solutions is made, identifying logistic improvements and technological innovations for the increase of the sustainability.

The study carried out is at an early stage and relates only to the identification of possible improvements.

Future developments will concern a feasibility study and an appropriate evaluation to compare the current status of companies with the one following the introduction of technological innovations.

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