# Factors influencing the implementation of new sustainable logistic models within dairy supply chains: insights from a multiple stages case study research

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**Abstract**: The dairy industry plays an important role in the agricultural economy of the European Union. Moreover, as a part of the agrifood sector, it is greatly exposed to the challenges of the Sustainable Development. In particular, the literature has recently put a strong emphasis on the need for improving environmental performance of such industry. One of the reasons regards the environmental impact of the logistics processes, especially the transportation of the products. Implementing innovative green supply chain management (GSCM) practices (i.e. the set of techniques used to increase environmental performance of the supply chains) might be a solution. Nevertheless, the practical adoption of GSCM practices is still far from widespread. In fact, the dairy supply chains are plagued by high risk and uncertainty, which often prevent managers to move towards sustainable solutions. The purpose of this research is to understand the main factors influencing the adoption of innovative GSCM practices within the dairy supply chains. In particular, given its relevance, the focus is on the introduction of new sustainable logistics models with the perspective of the entire supply chain. Accordingly, a multiple case studies research in multiple stages (producer, logistics operator, and supermarket) of Italian dairy supply chains has been performed. This allows the researchers to empirically explore the context and collect data from different actors of the supply chain. The findings support the identification of factors affecting the implementation of new sustainable logistics models in the dairy supply chain. They can be classified as KPIs (e.g. delivery and financial performance), technology and features of the logistic model (e.g. track and trace technologies, traveling stock) and exogenous factors (e.g. weather conditions). The factors are different from one stage to the other, due to dissimilar needs. The resulting framework supports companies operating in the dairy industry to implement innovative GSCM practice.

**Keywords**: dairy supply chain, green supply chain management, sustainability, multiple case studies

## 1. Introduction

The agrifood industry is facing different challenges connected to sustainable development (Glover et al., 2014). These challenges triggered initiatives ranging from food waste reduction and management programs, to new solutions to contain the environmental issues related to the use of natural resources and different forms of pollution generated in the core processes (Godfray et al. 2010). In such industry, authors (e.g. Zouaghi and Sanchez, 2016) identified in radical innovations oriented to sustainability not only a risk mitigation, but also a growth strategy. Among the different types of agrifood products and related supply chains, in the present study, we focus on the dairy supply chain, which is considered to be particularly energy intensive (Glover et al., 2014), with products that are highly perishable and need constant refrigeration, with daily shipments (Glover et al., 2014). For these reasons, the environmental impact of transportation is particularly critical. The characteristics of the vehicles adopted in the dairy supply chain, as the fact that they are refrigerated and on roads, directly impact on $CO_2$ emissions (Validi et al., 2014).

The application of intermodal rail-road transportation, i.e. the load is transported in the same transportation unit through different mode of transports (i.e. by rail and on roads), could be a solution to reduce $CO_2$ emissions (Colicchia et al., 2017). Nevertheless, the perishability of the dairy products requires transport integrity, frequent deliveries in low volumes, together with temperature-controlled to assure the preservation of the organoleptic properties. These characteristics are not assured by intermodal transportation, due to the big size of the existing intermodal refrigerated transport units and the long distances. Moreover, the temperature-controlled performance is not appropriate with the current technologies.

This paper aims at investigating an innovative set of Green Supply Chain Management (GSCM) practices connected to the implementation of a new logistics model that reduces the environmental impact of the dairy supply chain. The new logistic model consists of the paradigm of modular and intermodal transportation units. The logistic process is innovative due to the application of a new technology that has been already developed and is now under study for the commercialisation. It is a temperature-controlled transport units based on phase-change refrigeration technology with no engines needed, able to assure a constant temperature from 0 °C to +10 °C for 7 days (on average). The transportation unit represents one small-size module, able to contain one load equal to one EUR-pallet with variable height (max 160 cm, suitable to the typical size of the dairy transportation unit). Afterwards, the modules (i.e. units of transportation) can be combined together in a platform of 10 modules to be transported by rail and on road. Figure 1 depicts the transport unit and the modular platform.

This new technology serves for transportation of small quantities assuring the integrity of transportation of each single pallet. The technology is based on modules combination and allocation to different destination-based platforms - including long routes (e.g. Italian railway lines from Northern to Southern Italy, European railway lines) - which allow to keep a constant temperature in the unit by avoiding frequent openings. This overcomes the typical limits of the intermodal transportation units and the constraints typical of a cold chain providing a new sustainable logistics model. The value of each transportation unit is around 1,500.00 € and can be considered competitive with the refrigerated transportation units currently present within the market.

**Figure 1: the transport unit and the modular platform**

The abovementioned logistics practices positively impact on environmental performance of the dairy supply chain; thus they can be considered GSCM practices. In particular, intermodal transport is hereby proposed as a solution to manage the trade-off between the service level and the reduction of the environmental impact optimally (Dekker et al., 2012). Likewise, through modular dimensional coordination, the transportation process gains in space efficiency, therefore reducing transportation costs, time and emissions (Grönman et al., 2012).

Finally, the new technology is likely to allow further implications for sustainability in broader terms. For example, the refrigeration technology is capable of preserving fresh and frozen food longer, decreasing the probability to generate food waste. In particular, the limited dimension of the transportation unit could allow to ship smaller quantities directly to the distributor without intermediate re-packing. This fosters the reduction of the number of stocks at the distributor that are expose to the risk to reach the expiration date. Moreover, such innovative technology allows to reduce product damages caused by non-constant refrigeration temperatures.

Given that the set of GSCM practices and their potential impacts on the dairy supply chain present innovative and unique applications, with the present study, we aim at investigating the factors that foster or hinder the adoption of such practices by different supply chain actors mostly impacted by the innovation (i.e. manufacturer, retailer and logistics provider). Moreover, we aim at understanding which of these factors are necessary conditions for a certain supply chain actor to welcome the innovation and which instead are desirable attributes or "nice to have features" to be considered. Different technological, strategic and contextual factors emerged for different stages of the supply chain.

The paper sets out as follows: first, we introduce the theoretical background (sections 2), followed by the presentation of the research framework (section 3) and methodology adopted (section 4) leading to findings (sections 5), and conclusion (section 6).

## 2. Background

Transportation of temperature sensitive and perishable products requires a special type of logistics and supply chain management, targeted to assure food safety and quality from the manufacturer to the consumer. Therefore, any innovation to be introduced in the food cold supply chain should consider its characteristics: (i) need of temperature monitoring and control, (ii) importance of compliance with regulations, (iii) fast deliveries while assuring (iv) economic convenience (Badia-Melis et al., 2018; Kuo and Chen, 2010; Zhang, Habenicht and Spieß, 2003).

Transportation of goods, especially in the intermodal rail-road, is subject to security disruptions, e.g. damages, thefts, un-authorized manipulation (Cigolini et al., 2016). Therefore, any innovation introduced should consider the security issue, as well as not affecting the effectiveness of tools already in place for assuring security.

Moreover, the introduction of an innovation in the supply chain requires also other supply chain management decisions to be adjusted accordingly. For instance, if shifting to intermodal rail-road transportation from pure road transportation, inventory levels should be increased, along with delivery windows, and planning and ordering should be improved to adjust to the lower flexibility of rail (Eng-Larsson and Kohn, 2012).

Among the GSCM practices that can be applied in the transportation of goods, intermodal road-rail transportation is one of the most powerful tools that helps reducing the $CO_2$ emissions of supply chains (Eng-Larsson and Norrman, 2014). However, the introduction of intermodal road-rail transportation into a supply chain is hindered by various factors (Meisel, Kirschstein, and Bierwirth 2013). The study by Colicchia et al. (2017) presents a classification of these factors into: (i)

Operational and quality factors, i.e. performance to be evaluated when deciding for shifting to intermodal, e.g. lead times, reliability, flexibility, safety from damage (Monios, 2015) (ii) Product-related factors, i.e. features of the transported good that might make it unsuitable for intermodal transportation, and (iii) Supply chain management factors, i.e. supply chain planning decisions that might hinder the effectiveness of the intermodal rail-road transportation.

Food safety, quality and security assurance require an effort not only by each single actor of the food chain, but also tight coordination along the supply chain (Beulens et al., 2005). Therefore, any innovation introduced should take into account the implications for all the actors of the supply chain and should be designed to assure that all the actors would support its introduction. Despite this, there is a lack of research regarding the introduction of innovative GSCM practice in a supply chain perspective.

## 3. Research framework

This research aims at investigating the factors that might support or hinder the adoption of GSCM innovative practices with a supply chain perspective. Therefore, we aim to provide an answer to the following research questions (RQs):

(RQ1) Which factors foster or hinder the adoption of innovative GSCM practices by the different supply chain actors mostly impacted by the innovation?

The innovative GSCM practices considered are the introduction of a newly conceived refrigerated transport unit (i.e. the technology), that allows the use of intermodal transportation also in the dairy supply chain. The transport unit can be successfully used if associated to a change in the way the supply chain is managed (i.e. the logistic model). For instance, it requires to manage the return of the transport units. In fact, the unit is filled with dairy products at the manufacturer, then it is transported by the logistics provider to the retailer, and then it should be returned to the manufacturer. Therefore, the three main actors affected by the innovation are: the manufacturer, the logistics provider and the retailer.

After factors are collected, we aim to analyze the different effects on the different actors. Therefore, we aim to provide answer to the following research question:

(RQ2.) Which of the identified factors are necessary conditions to a certain supply chain actor to welcome the innovation and which instead are desirable attributes or “nice to have features” to be considered?

Depending on their position in the supply chain, different actors might have different needs and, therefore, might perceive each factor as more or less important than other actors.

## 4. Methodology

The methodology chosen to conduct the empirical analysis and answer to the abovementioned research questions was a multiple case studies research in multiple stages of the supply chain. This method enhances the rigor of the research in the supply chain management field (Seuring, 2008). It allows the researchers to analyse the decision-making process empirically, driving the implantation of new sustainable logistic models within different actors of the supply chain at three different stages: manufacturers (M), logistic providers (LP), and retailers (R). The LP stage includes also the intermodal operator which is still not part of the dairy supply chain but will be included in the new logistic model. The unit of analysis in this study is the company and the research sample has been chosen amongst companies operating in the Italian Dairy supply chain. Companies of different size and market positioning have been interviewed for the purpose of increasing the generalizability of the results. Semi-structured interviews with one or two managers per company (depending on the case: supply chain manager, CEO, logistic manager, quality manager, project manager, marketing manager, sales and business development) provided the main source of data collection, supported by companies visit and secondary data (websites, internal documentations, etc.). In Table 1 the case studies overview is shown. Figure 2 depicts the relationships between the case studies. It can be noticed that each case in one stage is connected with at least one case in one of the other stages. “Other” refers to logistic providers that were not included into the sample but deliver to the interviewed retailers. These companies were not included, in order to have a sample size that allows in depth-analysis of each case while having a balanced number of cases per stage. As stated above, the intermodal operator is not part dairy supply chain yet, therefore there are no relationships between this actor and the others at this stage. Nonetheless, one of the case study (R) is representative of an Italian intermodal operator currently serving other markets.

**Table 1: Case studies overview**

| Manufacturers | Employees | Revenues [million €] |
|---|---|---|
| A | 3,500 | 900 |
| B | 304 | 127 |
| C | 150 | 80 |
| D | 80 | 25 |
| E | 1,000 | 700 |
| F | 13 | 2 |
| **LP** | | |
| G | 744 | 270 |
| H | 1,500 | 97 |
| I | 1,000 | 205 |
| J | 500 | 215 |
| K | 1,400 | 117 |
| **Retailers** | | |
| L | 20 | 4,900 |
| M | 5,200 | 1,100 |
| N | 180 | 1.2 |
| O | 2,000 | 850 |
| P | 300 | 1,800 |
| Q | 10,000 | 1,600 |
| **LP (intermodal operator)** | | |
| R | 42 | 54.1 |

The questionnaire proposed to the interviewees was based on a set of questions related to the new technology. The aim was to understand the main benefits and problems that the companies expect from the application of the new technology. Starting from the description of the as-is processes that now involve the traditional technologies (i.e. refrigerator trucks) and the main criticalities within them, the discussion was conducted to understand a potential to-be scenario where the new technology can be applied.

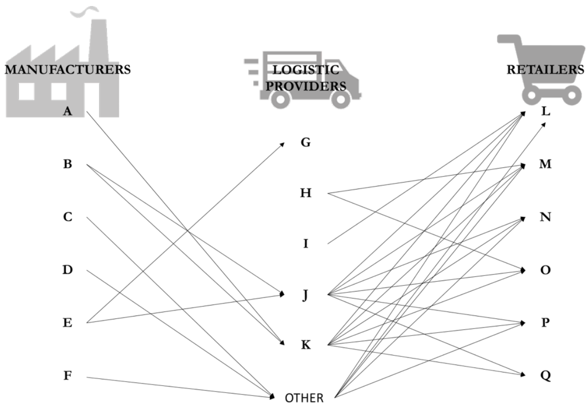


**Figure 2: The relationships between the interviewed companies**

## 5. Findings

The analysis of the data collected allows the researchers to identify the factors affecting the implementation of new sustainable logistics models in the dairy supply chain. First of all, the companies described their as-is logistic model and define the "must have" factors that would influence the choice to implement a new sustainable logistic model.

### 5.1. The as-is model

The as-is logistic model described by the companies is based on transportation of dairy products in refrigerator trucks that contain 33 pallets each, often mixed in terms of both manufacturers and retailers. They usually keep one single temperature inside or multi-temperatures thanks to truck insulated bulkheads installed. This solution is defined by the companies as not sustainable due to the $CO_2$ emission of the truck delivery. The final customers are becoming everyday more sensitive to these themes, but the complexity to implement an intermodal system with the current transportation technologies makes it impossible to apply more sustainable solutions. Therefore, after the presentation by the researchers of potential alternatives to apply a more sustainable logistic model based on the implementation of new technologies, the companies expressed their interest in the proposal. Nevertheless, the actors interviewed were all sceptical about the implementation of changes in their current logistic model due to extremely complex characteristics of the dairy products and their delivery. The actors belonging to the different stages, identified distinctive challenges that the new logistic model should face based on their needs, which change along the supply chain.

### 5.2. The factors for the manufacturers

The dairy product is characterised by a short life time and it is very easy to deteriorate. For this reason, it is very important for the manufacturer to maintain the quality and the organoleptic characteristics of their products during the delivery. Therefore, they consider factors mostly related to KPIs a "must-have" in the implementation of a new logistic model: (i) temperature control: a desired temperature range must be assured to avoid quality losses and food waste during the delivery; (ii) delivery lead time: the delivery performance expected by their customers (i.e. the retailers) must be assured in terms of speed and feasibility; (iii) transportation cost: the cost of the logistic service must be competitive with respect to the as-is logistic model; (iv) delivery size and frequency: deliveries must be flexible in terms of size and frequency based on the customers' needs (usually small frequent deliveries are preferred to keep the stock turnover high). Important "nice to have" that manufacturers imagined for the to-be scenario, are related to the technologies and features of the logistic model: (i) real time temperature traceability: in addition to the constant maintenance of the temperature, its traceability thanks to specific track and trace systems installed in the transport unit would be useful to monitor the performance; (ii) integrity of transport: in addition to the delivery size and frequency, the possibility of saturating each transport unit by sorting the deliveries based on customers would allow the integrity of transport from the manufacturer to the retailer (i.e. the unit of transport is never opened along the chain) and reduce the exposure of the product to temperature changes, preventing food waste.

### 5.3. The factors for the logistic providers

On the logistic providers side, the main "must-have" factors are mostly related to the technologies and features of the logistic model: (i) size and weight: the size and weight of the transport unit must not reduce the transportable quantity (the weight of the products has a value and must be maximised) and/or increase complexity in the handling activities; (ii) resistance and durability: the transport unit implemented in the new logistic model must be resistant to the possible damages along the chain; (iii) transport unit conformity: the performance of the technology applied must be conformant with respect to what the customer expects (temperature, transportation integrity, etc.) and not be reduced over time; (iv) transport unit maintenance: the time and money losses due to maintenance activities must be reduced at the minimum level. Moreover, also in this case KPIs were considered: (i) delivery lead time: the time required by the customer (manufacturers) must be assured; (ii) transportation costs: the transportation costs must not be negatively affected and keep high competitive advantage; (iii) cost and environmental impact of reverse logistic must be optimised and (iv) environmental impact of transportation: sustainability of the transportation technology can be a source of competitive advantage because of the final customers awareness to environmental issues. Important "nice to have" factors that logistic providers proposed for the to-be scenario are both KPIs and technologies and features of the logistic model. The inter-modality factor is seen as a "nice to have" strategic factor: the possibility to increase sustainability by applying mixed transport modes is very important for the logistic providers; moreover the distances covered could increase, making it possible to reach different markets. Nevertheless, there are some exogenous factors here that have been underlined by the retailers and must be considered in this application: (i) the weather conditions: too cold or too hot temperatures can negatively affect the technology performance; (ii) organisational issues can cause long stops during the delivery (delays due to national strikes, unexpected breakdowns in the transportation line, social events, etc.); (iii) thefts and damages: they represent a risk along the chain that is very hard for companies to completely avoid. For example, not only did problems related to the use of rail transport cause the reduction of performance of new transport technologies, but they also negatively affected the entire supply chain, including lengthening delivery times. Also, damage and theft are mostly related to the costs that may arise when such events occur, because, for example, the damages can make the unit of transport (holes, breaches, etc.) less efficient because of temperature losses. This means that damage can often have serious repercussions on the performance of transport technologies. As a consequence three "nice to have" technological characteristics and features of the logistic model that could help in facing this problems are: (i) long temperature autonomy: the possibility to keep the desired temperature range for a time longer than the one expected for the delivery and considering the weather, to keep safe the product quality even during a long stop; (ii) the delivery of independent mixed transport units: the application of mixed transport units that are independent assures that each single product is not negatively affected in terms of quality and its organoleptic characteristics by the other products delivered in case of e.g. melting; (iii) real time location track and trace: specific track and trace systems installed in the transport unit would be useful to monitor the location of the transport units every time companies need it.

### 5.4. The factors for the retailers

Retailers have paid particular attention to the following KPIs: (i) the delivery lead time and the (ii) frequency and size of the delivery. The shelf life of the product depends on transportation lead time, which need to be shortened. They consider essential ("must-have") that the products arrive with an acceptable shelf life and "nice to have" the possibly to increase the as-is shelf life of the products. In this perspective, they considered interesting the use of new transportation technologies (technologies of the logistic model) along the supply chain that could positively influence the shelf life of products and increase the frequency of reception of goods in such a way as to have small volumes and fresh products. It is also of interest that only retailers have rated as "very useful" having transport units available that could also be used as real "travelling stock", i.e. a transportable refrigerated warehouse. In particular, for those retailers who are moving towards online sales, this interest stems from the fact that in some cases the delivery points have a refrigerated warehouse particularly small or they do not have one. Therefore, the long temperature autonomy is an object of interest for these actors as well. Finally, the exogenous factors defined by the logistic providers (weather conditions, organisational issues, and thefts and damages) have been confirmed by the retailers.

## 6. Discussion

Table 2 provides a summary of all the factors identified by the actors. The factors have been labelled based on the following categories: (i) KPIs, which are related to the critical success factors of the company and its strategical goals; (ii) technologies and features of the logistic model, which are related to the technological or physical characteristics of the technology (i.e. the transport unit) that can support the logistic system to fulfil the needs along the supply chain; (iii) Exogenous factors, which are related to the characteristics of the supply chain that are out of company's control. The bold uppercase cross means "must-have" and lowercase cross means "nice to have" for the KPIs and the technologies and features of the logistic model, while the tick is used for the exogenous factors.

The actors of the supply chain demonstrated to have very different perspectives in terms of factors that must be considered to adopt a supply chain innovation towards sustainability. Therefore, these differences should be taken into account by the developers of the technology and the new sustainable logistic model.

On the one hand, upstream and downstream actors of the dairy supply chain (i.e. the manufacturers and retailers) are mostly focused on the quality of the dairy product that must be sold to the final customer, and its dependence on the perishability. For manufacturers, the focus on quality and food safety is also connected with a specific attention put on the food waste issue.

These considerations lead to base the assessment of the to-be logistic model on the capability to equalise and, if possible, to improve the KPIs of the as-is scenario, particularly in terms of quality, but at the same time not compromising lead time and cost performance.

On the other hand, there is the intermediate actor (the logistic provider), which is concerned with assuring the required service level to its customers (i.e. manufacturers), while keeping high financial and sustainable performance. It is straightforward that the factors related to the technology are mostly proposed and considered by the logistic provider, and mostly related to "must-have" classification. This interest related to the technologies is because the logistic provider is the actor that will use (buying or renting) the transport unit and will manage it to provide the best possible logistic service to the customers.

One important thing to discuss based on the fact that the actors have often different preferences is that they are sometimes incompatible. This generates important trade-offs that must be managed along the chain.

An example of a trade-off between the various players is represented by the fact that the logistic provider, on the one hand, would like the new transport technology to be as light as possible in order to transport more payload; on the other hand, however, the manufacturer want to guarantee the temperature control and the retailer would like a longer shelf life: this is possible only applying coolant to the refrigerating technologies, which increases the weight of the transport unit.

**Table 2: Identification of factors according to Manufacturers (M), Logistic Providers (LP), Retailers (R)**

| | | Factors | Supply Chain Actors | | |
|---|---|---|---|---|---|
| | | | **M** | **LP** | **R** |
| **KPIs** | | Delivery lead time | X | X | X |
| | | Transportation costs | X | X | |
| | | Temperature control | X | | |
| | | Delivery size and frequency | X | | X |
| | | Cost and environmental impact connected to the implementation of reverse logistic | | X | |
| | | Environmental impact of transportation | | X | |
| | | Longer shelf life | | | X |
| **Technology and Features of logistics model** | **Technology** | Real time temperature traceability | x | | |
| | | Size and weight of the transport unit | | X | |
| | | Resistance and durability of the transport unit | | X | |
| | | Transport unit conformity | | X | |
| | | Transport unit maintenance | | X | |
| | | Long temperature autonomy | | x | X |
| | | Independent transport units | | x | |
| | **Features** | "Traveling stock" | | | X |
| | | Real time location track and trace | | x | |
| | | Integrity of transport | x | | |
| **Exogenous factors** | | Weather conditions | | ✓ | ✓ |
| | | Organisational issue | | ✓ | ✓ |
| | | Thefts and damages | | ✓ | ✓ |

The trade-offs, in some cases, can also be detected within the same actor in the supply chain, such as the case of the logistic providers. As shown in the table, logistic providers consider the size and weight of the transport technology to be a must-have, but at the same time claim that this technology also must have very high durability and strength performance. Obviously, even in this case, it becomes very difficult to reconcile these two needs given the fact that resistant materials are heavy. Therefore, it is necessary to find a compromise not only between the needs of the different actors, but also between those of the same actor.

What it is very important to understand is how to be able to find a mediation among all the factors in order to make the new sustainable logistic model suitable to the entire dairy supply chain.

## 7. Conclusions

This paper proposes a multiple case studies research performed in three stages of the dairy supply chain. The main contribution of this study consists in the identification, definition, and structure of a set of factors that must be taken into account by companies implementing a new sustainable logistic model for the dairy supply chain. Strategic, technological and physical, and exogenous factors have been identified to make the implementation effective. The set of factors provided have been distinguished from one stage to the other along the supply chain.

The results confirmed the importance of the implementation of new technologies that could help the dairy supply chain in increasing the sustainable performance and reduce the impact that it currently has on the environment. At the same time, the complexity in implementing changes in the as-is logistic model has been underlined: the different actors have different preferences, conflicting between the actors and within the same actor. There are characteristics that must be kept in the new logistic model and others that should be introduced to make it more appealing.

The findings allow for outlining a final list of factors that could be considered by researchers within this field as tool to support the development and introduction of new products/technologies for sustainable logistic models.

The main limitation of the study is based on the fact that one single solution has been presented to the companies during the data collection. This makes the data collected biased with respect to the product characteristics: modularity, intermodality, and advanced refrigeration technology. Therefore, further research is welcomed to increase the number of companies analysed and to study their reaction to different products/technologies that support the implementation of new sustainable logistic models.

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