Seeking new strategic options for promotion of intermodal transport in perishables: the use of Short Sea Shipping

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Abstract

The objective of this study is to find new options for the promotion of intermodality, based on short sea shipping, as applied to perishable products. At present, most of the transport is carried out by refrigerated trucks. In theory, this change would have positive effects on the environment and could even reduce transit costs, but companies are still hesitant to implement this practice. In this context, the present study aims to determine whether there are aspects other than operational considerations (e.g., time, cost, quality or environmental concerns) that condition modal shift. First, a literature review is conducted which attempts to identify both the strengths and

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weaknesses of intermodality in perishable transport. This review serves as the basis for the elaboration of a questionnaire targeting transport actors within the fruit and vegetable supply chain in southeastern Spain – the area taken as an application example. Next, the survey is used to determine the possible drivers that would favor a modal shift applying a structural equation analysis, corroborated with a traditional econometric model. As a result, the design of an overall strategy based on the creation of redistribution hubs at destination (i.e., located at ports), whose operations could be optimized through the digitization of the supply chain, appears to be a promising approach.

Key words: modal shift, international transport, perishables products, redistribution centers, short sea shipping.

1. Introducción

In recent years, public administrations in Europe have sought to promote a shift from road transport to sea shipping by means of intermodality to achieve a rebalancing of the transport sector. In theory, this shift would have positive effects on both the environment and society as a whole. However, members of the supply chain are still hesitant to implement this change. This reluctance is much stronger in the case of perishable goods, which feature critical factors such as product quality. The present article analyzes this problem, not only from the operational point of view, but also from a strategic perspective. Our approach is to seek new ways of promoting intermodality (i.e., truck combined with short sea shipping) for the transport of highly perishable products, beyond those merely related to shortening transit times or cost reduction.

At present, refrigerated trucks are the most common option in international transport for ensuring that perishables are preserved in order to meet customer expectations. Today, 90% of transport of perishables utilizes this system in the EU (estimate from Eurostat, 2022). Its combination of flexibility, speed, transparency and ease of use makes competing difficult for other alternatives. One drawback, however, is a rising trend in cost, which is not the result of fluctuations in fuel prices but rather the restrictions imposed on trucks due to their environmental impact. Bear in mind, that in an international transaction, the transport of perishables by truck represents between 20-30% of the cost, insurance and freight (CIF) price of the product at destination (Spanish Ministry of Transport, and ICEX, 2023). In other words, as the price of transport by truck increases (this is an example of internalization of externalities), it becomes less attractive (Ramalho & Santos, 2021). This demonstrates the need to seek out alternatives or complements for the transportation of this type of merchandise, both from the point of view of cost savings and to mitigate its environmental impact.

In the years to come, technological transition towards low or zero emissions technologies will make road freight transport less polluting, for example, through the incorporation of electric and autonomous trucks. However, such systems fail to address the impacts of road congestion or the need to build infrastructures. Another more medium-term solution is the use of intermodal transport, understood as a combination of truck with other alternative means, be it short-sea shipping or train. This option could be the fastest and most complete solution to the saturation of infrastructure capacity. What is more, in certain cases, it could speed up the logistics chain, reduce energy consumption and reduce environmental impact, in comparison to traditional truck transport. For example, this system can exploit both the vast loading capacity of sea transport and the flexibility of the road.

In this context, the present study begins by identifying the general problems and benefits that condition and support the implementation of intermodality for perishables in the framework of an international supply chain. Furthermore, potential solutions will be proposed for the implementation of such logistics into the perishables supply chain. In parallel, we will examine two issues that, although discussed in the literature, have not been thoroughly analyzed together, especially in the context of perishables. These topics include: i) the role of emerging technological improvements; and ii) the switch from a direct logistics system based on road transport to one focused on redistribution centers with intermodal use (road and Short Sea Shipping).

To illustrate the need to change the standard method in international transport of perishables, this work examines the exportation of highly perishable horticultural products from southeast Spain to all the countries in the European Union. In this specific case, considering the delays in railroad connections, sea shipping proves to be the clear intermodal alternative, as it is the most viable option in the short term for this region to expand its logistics portfolio.

As for the methodology, this work will first conduct a literature review that attempts to identify both the strengths and weaknesses of intermodality in the transport of perishables. This review will serve as the basis for the elaboration of a questionnaire intended for actors in transport within the horticultural supply chain in southeast Spain, the area that will serve as a case study. The information compiled will serve to gather the direct opinions of transport users, but also to determine the possible drivers that would favor a modal shift, applying a correlation analysis using structural equations. Finally, solutions will be proposed which optimize the international logistics management of this type of product.

2. Intermodality in perishables: Strengths and weaknesses

Various articles have addressed the modal shift from road haulage to short sea or rail transport through an intermodal system in general terms (Raza et al., 2020), yet few have done so for the specific case of perishables. However, the international trade of this type of product is growing as a result of the increase in demand and its potential to attract customers when sold in traditional retail formats. For example, between 2002 and 2022, EU trade in vegetable products tripled, equating to an average annual growth of 5.9% (Eurostat, 2022). Therefore, this section presents the main strengths that would favor the incorporation of intermodality into perishables supply chains.

When viewed in general, however, there are many more drawbacks than advantages (Table 1). Nevertheless, many of these disadvantages could easily be overcome through the improvement of collaboration and communication among the various stakeholders involved. Furthermore, a proper understanding of the system could aid in modal shift. For example, the environmental benefits are evident when dealing with transport combined with train (Rossi et al., 2021), yet, in the case of Short Sea Shipping (SSS), the impact depends on the total distance traveled by sea, raising doubts about its general reduction of CO_2 emissions (Hanssen et al., 2012). On the other hand, other advantages are sufficiently demonstrated in the form of reduced accidents, noise and congestion (European Commission, 2015). Intermodal cost is also a clear advantage, as savings can reach over 20% in the case of land transport (Yakavenka et al., 2020), which can even improve as the volumes being shipped increase (Hanssen & Mathisen, 2011). Nevertheless, prices could vary, e.g., if these means of transport are operated by the same group, the lack of competition will negatively affect the offers for end-users. As the lines consolidate, new transport operators may be interested in offering their services, and prices would improve. An additional positive aspect cannot be ascribed directly to intermodal transport, as it corresponds to the tight regulatory restrictions on the use of trucks as an international transport method, coming in the form of ecotaxes, road tolls and reduced hours of service by truck drivers (Hanssen & Mathisen, 2011; Raza, 2020).

The improvement of coordination through the use of intelligent transportation systems (ITS) adapted to intermodality has received considerable attention from researchers in recent years.

Connecting ports with rail hubs, air freight and land-based distribution could offer greater efficiency in how goods are moved, thus reducing operation costs, energy consumption and vehicle ownership, and at the same time delivering greater reliability with predictability, which is vital in the decision-making process of the logistics value chain (Zhu et al 2019; Pal & Kant, 2019; Muzylyov et al., 2020; Harris et al. 2015). Despite its strengths, this point is a multi-faceted issue, meaning that, on the whole, its impact is not sufficient to warrant the modal shift.

An aspect which has been scarcely addressed in relation to the transport of perishables is the acceptance of intermodality as the preferred formula of consumers (Rossi et al., 2021). Nonetheless, a clear trend exists towards the consumption of products with minimal transport (local or regional products), thereby reducing carbon footprints. Indeed, this aspect confers intermodality a possibility of becoming the preferred means of transport for goods which must be imported due to the impossibility of being obtained locally through a careful energy balance. For example, in comparison to the horticultural products produced in southern Spain (solar greenhouses), those in northern Europe require considerable heating and artificial light inputs (Valera et al. 2014).

The weaknesses of intermodality for perishables are more varied than the benefits, with the existence of negative synergies on occasions. For example, the inability to achieve minimum loads that guarantee the viability of routes (Hanssen & Mathisen, 2011) conditions their preservation, at least during early stages, due to the substantial initial public and private investments involved (Douet & Cappuccilli, 2011; Pérez-Mesa, et al., 2012), circumstances that also exist with other types of goods. Overall, this situation also results in cancellations and excessive transit times (Dullaert & Zamparini, 2013; Cai et al., 2013), which are crucial in the case of perishables, as they cause degradation in the final quality of goods (Rong et al. 2011; Cai et al. 2013; Yan et al. 2020). In addition, there are other operational disadvantages to consider: lack of coordination, organization and implementation of frozen cargo (Filina-Dawidowicz, & Stankiewicz, 2021; Guo et al 2017; Aung & Chang, 2014; Akkerman at al. 2010); or even difficulties when the time comes for the loader to properly evaluate the key variables that affect a shipment of perishables, that is, time and cost (SteadieSeifi et al., 2014)

Another critical point is the coordination of loading companies, shipping companies, land-based transport companies and customers. Undoubtedly, intermodality requires fluid communication, excellent coordination (Behdani et al 2014; Guo et al 2017) and a strict policy of information exchange (Fan et al. 2020). The implementation of Information and Communication Technologies (ICT) to facilitate trade and transport can help in this regard, yet it has still been found to be incompatible with certain systems (Behdani et al 2014; Perego et al. 2011). Highly perishable products require that all these processes be "fine-tuned": their value at destination depends on it.

In general, works on intermodality focus on operational problems, including those related to technology or aspects of quality. Only a few studies delve into the reasons that impede modal shift. For example, some choose to use survey methodology targeting members of the supply chain, which is quite an interesting approach considering that the coordination of this group is of vital importance to a modal shift (Colicchia et al., 2017). What is more, no studies have developed any strategies that attempt to establish a new action framework. The reasons for modal shift are nearly always related to lower cost, including the externalities it carries. There is a need for further justification.

In this line, the fact that intermodality requires loading points and intermediary facilities at certain stages (Xiao, Y., & Chen, J. 2012; SteadieSeifi et al. 2014; Yakavenka et al. 2020) is normally seen as a drawback. However, recent works highlight that the transformation of these locations into redistribution centers for perishables offers important advantages (Morganti & Gonzalez-Feliu, 2020). One positive aspect is that goods can be returned to the supplier for a variety of reasons. At present, the products are simply disposed of due to the impossibility of returning them to origin, but, with this alternative, the products can be repackaged and served again to customers. Another advantage of redistribution centers is that they can maintain a strategy of fast and agile (flexible) service to customers. It is worth noting that this transformation would align well with consumer demands, and therefore with the intermediary customer (large retail distribution), which demands a more sustainable product that minimizes intermediate losses. Also, this strategy would be framed within intensive supplier-customer collaboration in an ad hoc supply chain that is easier to implement than the previous strategy (which assumes the existence of multiple customers and a more difficult demand to anticipate). For suppliers, this system would thus constitute a proactive strategy, generating more stable relationships with customers. This can improve capacity to attract more small retailers that require a more continuous service.

In short, implementing a redistribution strategy at specialized centers, one which combines efforts to use intermodality, the reduction of environmental impact, the promotion of the circular economy and an agile response to customers, could serve to incorporate the international transport of perishables into a new “local/regional” chain scheme that customers demand, as long as it optimizes the sustainability of logistics management.

Table 1. Strengths and weaknesses of international intermodal transport of perishables using SSS

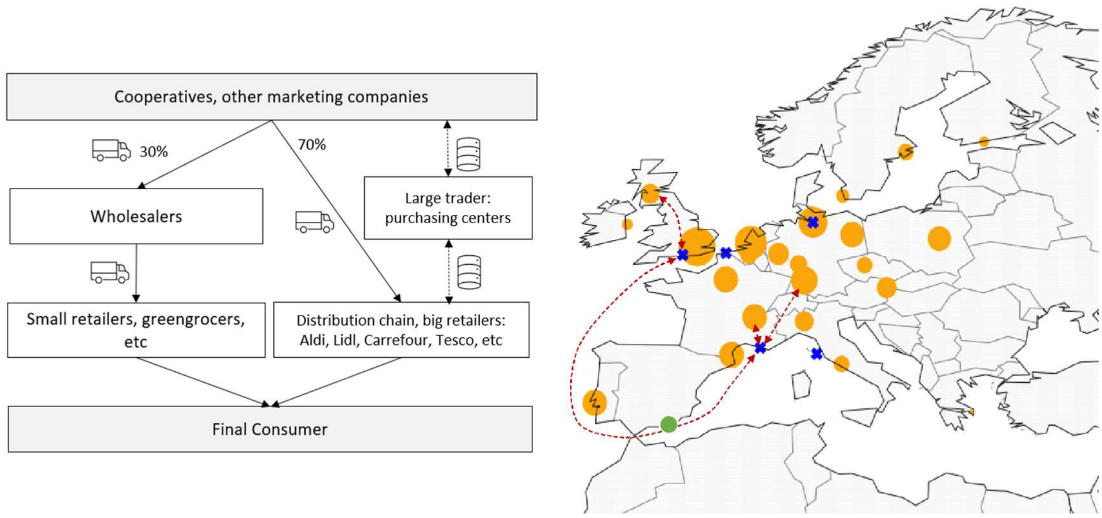
Strengths	Financial / Strategic	Capacity	Externalities	Regulatory	Technical
	▪ Less need for infrastructure investment compared to land transport (Pérez Mesa et al. 2012) ▪ Cost-effectiveness: Economies of scale (Hanssen & Mathisen. 2011; Yakavenka et al. 2020) ▪ New consumer trends: consumers prefer intermodal transport because it has lower CO_2 emissions (Rossi et al 2021)	▪ Underused shipping capacity and easy to expand transportation network capacity (Sambracos & Maniati, 2012)	▪ Reduced energy used: less air pollution (Hanssen et al. 2012; Cannas et al, 2020) ▪ Fewer accidents, noise emissions and less congestion (Rossi et al 2021; Yakavenka et al. 2020; European Commission, 2015)	▪ Restrictions on the use of the truck: imposition of ecotaxes and carbon taxes on truck fuels and more road tolls, also reduced hours of service by truck drivers (Hanssen & Mathisen, 2011; Raza, 2020)	▪ Significant improvements in coordination with intelligent transportation systems (ITS) (Zhu et al 2019; Pal & Kant, 2019; Muzylyov et al., 2020; Harris et al. 2015)
Weaknesses	Financial / Strategic	Service/ quality:	Operational	Communication / collaboration:	Technical
	▪ Need of investments in facilities by operators (Fan et al. 2020) ▪ High initial investments: need for public aid to maintain channels open at beginning (Douet & Cappuccilli, 2011; Baindur & Viegas, 2012) ▪ Need for hub-based distribution systems: need to transport large volumes (SteadieSeifi et al. 2014; Yakavenka et al. 2020)	▪ Problems of product quality in transportation and destination (Rong et al. 2011; Cai et al. 2013; Yan et al. 2020) ▪ Longer lead times at ports and in transit and slower speeds (Abbassi et al. 2018) Lower reliability (high number of possible contingencies) and lower frequency (Dullaert & Zamparini, 2013; Cai et al. 2013)	▪ Problems with routing and fleet planning (Baykasoglu et al. 2019; Dulebenets et al. 2016; Cai et al. 2013) ▪ Lack coordination, organization and Implementation of frozen cargo (Filina-Dawidowicz, & Stankiewicz, 2021; Guo et al 2017; Aung & Chang, 2014; Akkerman at al. 2010) ▪ Mismatches between truck and ship: loss of time in loading-unloading cargo, cargo transfer, administrative procedures at ports, etc. (Guo et al 2017) ▪ Need for temporary inventory: cold chain maintenance (Xiao, Y., & Chen, J. 2012) ▪ Need to guarantee minimum loads: adequate groupage needed (Hanssen & Mathisen. 2011; Orjuela Castro et al. 2021) ▪ Difficulties to assess multi-objectives (time/cost): users unsure whether time or cost is better (SteadieSeifi et al. 2014)	▪ Poor industry image: there are no marketing activities by SSS firms or rail firms (Hanssen & Mathisen, 2011; Raza, 2020) ▪ Weak communication and collaboration by firms (horizontal and vertical) (Behdani et al 2014; Guo et al 2017; Colicchia et al. 2017) ▪ Insufficient and unclear information available to users (Fan et al. 2020) ▪ Lack integration into door-to door transport chain: need for coordination between means of transport (Suárez-Alemán et al. 2015) ▪ Necessity of groupage of loads, requiring strong coordination: Very difficult in perishables due to the existence of a very volatile supply and demand. (Hanssen & Mathisen. 2011)	▪ Incompatibility of equipment and ICT or ITS systems (Perego et al. 2011) ▪ Absence of integrated management systems (Behdani et al 2014)

3. The example of vegetable transport from southeast Spain to Europe: intermodal options

Southeast Spain is the largest supplier of vegetables to Europe. 75% of all production is allocated for exportation (Figure 1), and its final destination is primarily important cities in Germany (27%), France (16%), the United Kingdom (14%) and the Netherlands (9%). Approximately 40% of all vegetables consumed in Europe come from Spain. At present, virtually 100% of transport is carried out by means of refrigerated truck (ICEX, 2023). The logistics involved in the horticultural supply chain are conditioned by its own characteristics (Figure 2). The most notable feature is the existence of a dominant company (hub or channel master), in this case represented by large retail distribution firms in Europe, namely chains like Auchan, Lidl, Aldi, Carrefour and Tesco. These firms operate through large purchasing centers, which have now also become logistics management companies that only manage information: they are dedicated to managing sales and purchases and logistics management (no storage or handling facilities). In this context, fruit and vegetable exporters control barely 25% of transport to destination. The groupage of cargo is the responsibility of the purchasing centers that manage the shipments. To implement intermodality, coordination among the supplier, the purchasing center and the customer would thus be of vital importance. As of today, suppliers receive details on transport logistics only a few days in advance, which complicates medium-term scheduling, which is so crucial for the modal shift.

From the geographical point of view, the region presents a series of characteristics that hinder logistics management: i) scarce railroad infrastructures that are mainly designed for only domestic travel, with no opportunity to create a "Mediterranean passageway" directly to France; ii) an adequate sea exit to the Mediterranean Sea, mainly to the ports of northern Italy and southeast France, although cost savings via SSS might not compensate the journey depending on the final destination where the goods are unloaded; iii) a possible connection with Atlantic ports in eastern Europe, although the duration of SSS transit could discourage its use.

Figure 1. Horticultural supply chain and unloading areas of exports from southeast Spain (Almería+Granada+Murcia). Metric tons.



Green= Origin of the merchandise; red=examples of intermodal routes; blue= example of relevant ports.

Source: own elaboration based on Pérez-Mesa (2022)

In the case of intermodality, exploiting the Port of Almeria is viewed as a viable option, as a portion of the harvested horticultural production from neighboring provinces (i.e., Granada and Murcia) could also be shipped from this location. The total exported volume from these 3 provinces is 4.8 million tons (Customs, 2021), with a value of 4.9 billion euros. Various works have analyzed the transport options (land and intermodal) according to different criteria (cost, transit time, externalities generated, agile service), as applied to the region of study (Perez-Mesa et al. 2010; Pérez-Mesa, 2022). Based on these criteria, it was possible to distribute the volume transported and even identify the most suitable ports. In this regard, several ports have been identified as possible options to become redistribution centers for vegetables from southeast Spain: namely, Southampton, Dunkirk and Hamburg, along the Atlantic coast, and Marseilles, on the Mediterranean. The results show that the best ports/locations for ensuring an "agile" strategy (fast customer response time) are Dunkirk and Hamburg.

As for the use of rail, as an alternative to SSS, there have been several attempts to create lines, for example: i) Alicante (Spain) to the Barking terminal (London); or ii) Valencia to Rotterdam (Cool Rail). The fundamental problem occurs when crossing the Spanish border. The axles have to be changed to switch from Spanish gauge to European gauge. This operation takes an average of 12 hours. The future, from a medium and long-term perspective, could be the "Mediterranean Corridor", a railway line that would link Algeciras (southeast Spain) with Perpignan (southeast France), running along the entire Spanish coast. This project requires the installation of twin-track freight-passenger rails with international track width, in addition to tripling the size of the current high-speed rail network and unifying railway standards with the rest of Europe. For now, there are a series of lines with double rails, third tracks or independent tracks with completely different projects and deadlines (Spanish Ministry of Transport, 2022). For these reasons, SSS may be a better option in the short to medium term. Furthermore, the railway option continues to prove deficient in terms of the transportation of perishable goods (Islam et al., 2016): it requires large-scale cargo groupage, which slows down journeys, and it lacks suitable cold storage infrastructures. On the other hand, freight reloading, comprising the so-called friction costs, is very expensive and time-consuming. In fact, it can represent between 25% and 40% of the total cost of rail transport. Altogether, these factors make rail an uncompetitive option for perishable goods compared to other transport systems. (Rossi et al. 2021).

4. Reasons for change: the opinion of supply chain members

4.1. Methodology

Opting to use the survey method is usually the result of a compromise between the objectives and the resources available (Richardson et al. 1995). In this case, the questionnaire is a vital part of the study's success. Elaboration of the survey began by identifying variables that influence the intermodal transport of perishables using news articles on the topic (Table 1). This stage served to obtain a general idea of the problem (Melander et al. 2019). The present study employed a mixture of quantitative and qualitative research methods to provide benefits of triangulation, corroboration and elaboration of correlation analysis (Brannen, 2005; Punch, 2013). In this sense, the proposed questionnaire attempts to obtain information to carry out an exploratory investigation in order to identify the drivers of the modal shift, which will be subjected to an econometric analysis to determine their significance and relative importance. The questionnaire targeted mainly participants and users of intermodal transport within the supply chain: fruit and vegetable commercialization companies in the study area (mostly cooperatives), logistics management companies, purchasing centers and supermarket chains. It proved difficult to obtain participants downstream in the supply chain, which led to the inclusion of primarily horticultural commercialization companies (exporters).

Based on the problems and solutions proposed in the literature, 12 questions were elaborated, structured in 4 blocks, which include and summarize the main variables that can influence modal shift. Block 5 (with 2 additional questions) is used to ascertain the predisposition of operators towards a modal shift from road transport to intermodality with SSS. The response method utilized is a Likert scale (1-7), where 1= completely disagree and 7 = completely agree. All the questions reference intermodality as related to transport of F&V.

- B1-Relevance of operational, service and quality improvements (4 questions), including the most important operational aspects that condition intermodality for perishables (cost, time, quality).
  - *Time* = Intermodality guarantees on-time delivery.
  - *Quality* =Intermodality guarantees product quality at destination.
  - *Cost* = The cost of intermodality is lower than truck.
  - *Environm* = Intermodality reduces environmental impact.
- B2-Relevance of communication and planning (3 questions). Collaboration among members of the supply chain represents the focus of the literature on the use of intermodality for perishables.
  - *Comun_Inter* = Intermodality becomes easier if communication/planning is increased between supplier and customer.
  - *Comu_Quali*= New technologies applied to intermodality improve planning by reducing transit times and enhancing quality.
  - *Comu_Cost* = New technologies applied to intermodal transport improve planning by reducing cost.

- B3-Possibility of redistribution centers at destination (2 questions). This attempts to explore the possibility of establishing points of storage and commercialization for fruit and vegetables near intermediary points. This block could have been included with the previous set of questions but was kept separate as it was a specific objective of the investigation.
  - *Center_Serv* = The creation of intermodal redistribution centers at destination for collaboration / planning between supplier and customer.
  - *Center_Compla* = The creation of intermodal redistribution centers would result in improvements by reducing complaints and waste.

- B4-Relevance of future changes (3 questions), primarily to gather information on how technological innovations can favor modal shift.
  - *Change_Inter* = In the medium and long term, changes will take place that will favor the Intermodal System.
  - *Change_Elec* = New solutions for road transport (electrification) will substitute SSS.
  - *Change_Less* = New transport solutions will decrease the relevance of sustainability in transport.

The following block was designed to analyze the predisposition of operators (users) towards the intermodal option in the medium and long term, considering that utilization is currently null:

- B5-Importantace of modal shift (2 questions). This dimension will be utilized later as an independent variable in an econometric modelling.
  - *Accept* = The incorporation of intermodality is important for the sustainability of the sector.
  - *Import* = I foresee in the medium and long term the incorporation of intermodality.

Regarding the sample, the survey was conducted between May and September 2022. The total number of completed surveys was 55 (39% from Almería, 35% from Murcia, 3.5% from Granada, and all others were from operators and intermediaries located in southeast Spain). As for company type, 80% were fruit and vegetable commercialization companies, 15% wholesale companies, 5% transport management or logistics operators, and 2% retailers. With regard to the representativeness of the sample, the 44 commercialization companies that responded to the questionnaire accounted for 1.4 million tons of fruit and vegetables, 26% of the total exported by southeast Spain. The inclusion of wholesaler, logistic operator and retailer was done with the aim of incorporating additional points of view within the supply chain. It is important to highlight that there are great difficulties in accessing these types of companies, especially retailers.

4.2. Analysis of survey

Table 2 displays the results according to frequency of response. An initial group of general questions reveals that operators have doubts as to whether intermodal transport can guarantee product quality at destination or be delivered on time. However, the majority recognize the environmental benefit and the possible cost savings that this type of transport can generate. In addition, these questions show that transit time is much more important than cost when deciding how to ship merchandise.

The block of questions that seeks to analyze the importance of communication, planning and new technologies that favor intermodality also obtained important findings. There is a consensus in that intermodality for fruit and vegetables could be feasible if communication / planning between supplier-customer increased. Another point of agreement is that new technologies applied to intermodal transport (blockchain, real-time trackability, smart market systems, improved forecasting) would help to reduce transit time and maintain quality at destination, and even lower service costs.

Tabla 2. Results of the questionnaire according to frequency

		1	2	3	4	5	6	7
B1	*Time*	4%	24%	25%	31%	7%	7%	2%
	Quality	0%	11%	27%	36%	9%	9%	7%
	Cost	5%	5%	22%	36%	22%	2%	7%
	Environm	2%	2%	7%	18%	40%	22%	9%
B2	*Comun_Inter*	2%	4%	13%	24%	27%	20%	11%
	Comu_Quali	2%	2%	11%	20%	31%	29%	5%
	Comu_Cost	0%	5%	9%	27%	31%	24%	4%
B3	*Center_Serv*	2%		11%	29%	27%	24%	7%
	Center_Compla	2%	4%	11%	24%	31%	24%	5%
B4	*Change_Inter*	5%	4%	15%	33%	27%	15%	2%
	Change_Elec	2%	4%	7%	25%	31%	20%	11%
	Change_Less	0%	4%	7%	25%	38%	22%	4%
B5	*Accept*	4%	7%	25%	27%	25%	11%	0%
	Import	2%	11%	13%	38%	24%	11%	2%

Higher frequencies in gray.

With regard to the supplier-customer relationship, another goal was to ascertain operator opinions about the possibility of creating intermodal redistribution centers at destination. In this sense, the majority think that establishing such facilities for fruit and vegetables based on collaboration / planning between the supplier and the customer could improve the service provided to the consumer, for example, maintaining both stability and supply of goods in shops while also reducing waste and complaints at destination.

There is also a majority consensus on the importance of changes in medium and long-term transport due to the impact of new technologies. The respondents vastly agree that new transport solutions, such as electric trucks, will substitute diesel in long-distance road transport. In contrast, there is a lack of agreement that considerable change towards an intermodal system using Short Sea Shipping for fruit and vegetables will replace traditional road transport. In other words, there may be more flexible and easier to implement alternatives to intermodality in the future.

Finally, regarding the acceptance and importance of intermodal service, the majority believe that the incorporation of intermodality using short sea shipping is important for the sustainability of the fruit and vegetable commercialization sector. However, few have plans to implement this service in the medium and long term.

These results seem to reveal a possible contradiction. The survey demonstrates that the companies in the fruit and vegetable supply chain believe more in the potential technological revolution of road transport than in the adoption of a modal shift. However, despite a certain degree of interest, there is no clear desire for implementation, probably because no one is willing to take the risk to initiate modal shift. The joint and coordinated use of redistribution centers at destination in combination with intermodality, on specific routes, could be a first step towards a shift. In spite of this general view, it is clearly necessary to consider new alternative logistics due to the unforeseeable problems that can arise in long distance land transport.

5. Hypothesis statement and design of a test model

At this stage, and according to the preliminary analysis of the bibliography and the preliminary results of the survey, a series of hypotheses are proposed regarding the possible determiners that could favor the modal shift. By applying the model design, these hypotheses attempt to demonstrate: 1) the statistical significance of the variables (survey questions) in the construction of the different blocks; and, 2) the relationship between the blocks themselves, according to the hypotheses proposed.

Precisely as the bibliography reveals, operational improvements play a key role in the promotion of the modal shift. The cost/time ratio, particularly in the case of perishables, becomes a crucial factor (Guo et al 2017; SteadieSeifi et al. 2014). Furthermore, there will be a direct relationship between these variables and any improvements made to both ships and loading procedures (Filina-Dawidowicz, & Stankiewicz, 2021; Abbassi et al. 2018), which result in both the reduction of externalities and more improvements in quality (Yan et al. 2020). In this sense it is intended to verify that:

H1. *Relevance of operational, service and quality improvements will have a positive impact on disposition towards the modal shift.*

Another key area of focus in the literature is the collaboration among members of the supply chain (Guo et al 2017). Weak communication and collaboration by firms (Behdani et al 2014; Colicchia et al. 2017) and insufficient information available to users (Fan et al. 2020) could be improved by new information technologies within comprehensive transport coordination and scheduling systems (Zhu et al 2019; Pal & Kant, 2019; Muzylyov et al., 2020). Such a scenario leads to the proposal of the following hypothesis:

H2. *Relevance of communication and planning based on the application of new technologies will have a positive impact on disposition towards the modal shift.*

In relation to the previous point, the design of authentic redistribution and consolidation centers, perfectly coordinated between the supplier and customer, which also achieve proximity to the consumer, could improve the reduction of complaints, the reuse (repackaging) of damaged merchandise, and even the capacity to attract local/regional small retailers that require a more continuous service (Orjuela-Castro et al. 2017; Caracciolo, 2018; Martins et al. 2018). New information technologies and, in general, the digitalization of the supply chain could facilitate improvements in the coordination of these centers, although the structure of the supply chain can certainly act as a moderating factor (Pérez-Mesa et al., 2021; Ben-Daya et al., 2019). In this line, the following hypotheses are formulated.

H3. *The creation of redistribution centers will have a positive effect on disposition towards the modal shift.*

H4. *Technological improvements in coordination and planning will facilitate the creation of redistribution centers at destination.*

Within the context described, one must consider how the accelerated trend towards reducing the use of fossil fuels and the increased presence of electrification (Hanssen et al., 2012); Cannas et al., 2020) could bring about an improved perception of transport, currently viewed as a pollutant sector, leading to either lost interest in the modal shift among operators or, on the contrary, increased support for said shift. Bearing these aspects in mind, the following hypothesis is proposed:

H5. *Future changes that affect transport will have a negative effect on disposition towards the modal shift.*

Prior to arriving at the definitive model design that the aforementioned hypotheses seek to verify, a preliminary analysis of the first and second order variables was carried out, including the correlation between them. A complete description is detailed in Annex 1 and 2. The reliability of the constructs was also analyzed using Cronbach's alpha, which was completed with a confirmatory factorial analysis from which the standardized coefficients and different tests were extracted for the interpretation of the model fit results: discrepancy (Chi Square) divided by degree of freedom, the Goodness of Fit Index (GFI) and the Tucker-Lewis coefficient (TLI). The results can be seen in Table 3. All the blocks behave consistently (Cronbach > 0.70) except for B4, as could already be observed in the correlations between the variables comprising this block (Annex 1). The problems with block B4 lead us to consider these variables individually in the subsequent analyses, reaching the conclusion that *Change_Inter* is the best explanatory variable in most of the models tested.

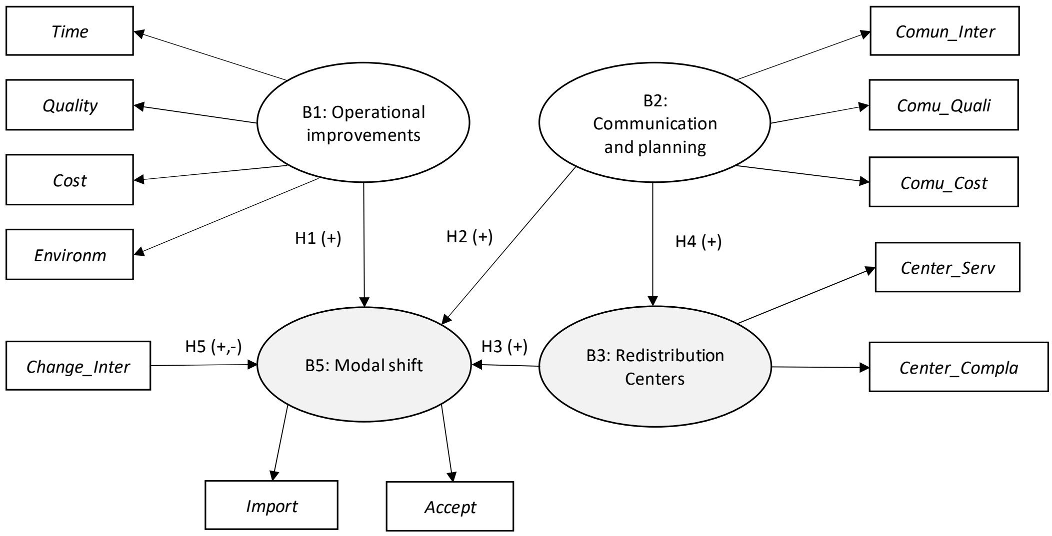
Table 3. Convergent validity of the blocks.

	Indicator validity and reliability		Construct validity & Fit Results			
	Stand. loading	Critical ratio	Cronbach's α	Chi/df	GFI	TLI Rho
B1			0.721	2.05	0.95	0.84
Time	0.50	2.953**				
Quality	0.59	2.837**				
Cost	0.83	2.992**				
Environm	0.60	2.855**				
B2			0.765	2.15	0.96	0.89
Comun_Inter	0.97	7.001**				
Comu_Quali	0.93	6.997**				
Comu_Cost	0.60	2.781**				
B3			0.853	2.04	0.96	0.84
Center_Serv	0.92	6.294**				
Center_Complaints	0.86	5.292**				
B4			0.531	6.502	0.93	0.24
Change_Inter	-0.23	-0.941				
Change_Elec	-0.66	-2.392**				
Change_Less	-0.36	-1.021				
B5			0.809	1.29	0.94	0.86
Accept	0.81	4.101**				
Import	0.91	4.737**				

Significant for p<0.01; ** Significant for p<0.05Significant for p<0.01; * Significant for p<0.1

Finally, the choice was made to design a structural equations model in keeping with Figure 2.

Figure 2. Model and initial hypothesis



6. Model results and discussion

Table 4 displays the results of the estimations using the Maximum Likelihood method, carried out with SPSS-AMOS. The results of the estimation appear to be suitable. The Likelihood ratio is χ^2= 44.76 (p=0.150), and the quotient χ^2 /gl presents a value of 1.243 (<3), showing that the indicators are optimal. The fit indices offer positive values (AGFI=0.85; NFI=0.88; TLI=0.949; CFI=0.966; IFI=0.91). The absolute fit indices also present acceptable values: RMR=0.067 and GFI=0.89, respectively. Regarding the HOELTER.05 index, which measures whether sample size can be accepted at the 0.05 level, obtained a value of 62 (based on a sample with 55 data entries). Thus, it is confirmed that, despite the rather small sample size, the results appear to be supported.

Upon analyzing the relationships, important aspects can be observed that reveal the complexity of the topic in question. The relationship between block B1 (*Operational improvements*) and Block B5 (*Modal Shift*) appear to be supported by the data (p<10%). Hypothesis 1 is corroborated, though a stronger relationship was expected, as most of the arguments gathered from the bibliography focus on this block: reduction in cost, improvements in externalities, influence of quality, and, of course, improved transit times. This leads us to ponder whether, at present, these aspects have been overcome and if the operator in the chain influences other, more strategic aspects. As for other data, block B2 "Communication and planning" has an important influence as a facilitator of the development of B3 "Redistribution centers", corroborating Hypothesis 4: *the digitalization of the chain would facilitate the coordination of all the logistics activities at these centers*. However, B2 has no direct influence on B5 "Modal shift", failing to confirm Hypothesis 2. It seems operators see no clear benefit of applying technology in relation to reducing cost or improving quality. This discovery is surprising, as clear arguments exist in favor of supplier-customer communication – the third explanatory variable of B2 – as a driver of modal shift. Perhaps the competitive structure of the chain has a bearing on this aspect. In contrast, Hypothesis 3 is corroborated: *the creation of redistribution centers at destination is a key factor for promoting the use of intermodality*. The advantages regarding a proactive strategy, entry to new markets, cargo groupage from different origins (re-exportation), or the reuse of returned goods from complaints are solid arguments in favor of implementing this system. Finally, Hypothesis 5 is not confirmed: *the members of the chain do not believe that future changes related to transport* (e.g., electrification) *have any bearing on the modal shift*. There is a view that technological change will not harm modal shift. It should be noted that the model also tested the remaining variables that comprised B4 individually (*Change-Ectr* and *Change_Less*), without obtaining better results.

Table 4. Estimation of structural equations model.

Block	Relation	Block /Variable	Estimate	Standardized Weights	Standard Error	Critical ratio
B3: Redistribution Centers	<---	B2: Communication and planning	0.593***	0.701	0.143	4.136
B5: Modal shift	<---	B1: Operational improvements	0.483*	0.327	0.282	1.710
B5: Modal shift	<---	B2: Communication and planning	0.197	0.216	0.174	1.132
B5: Modal shift	<---	B3: Redistribution Centers	0.440**	0.408	0.194	2.273
B5: Modal shift	<---	Change_Inter	0.098	0.124	0.120	0.812

Significant for p<0.01; ** Significant for p<0.05Significant for p<0.01; * Significant for p<0.1

To confirm the results achieved through the structural equation model, a new model (Table 5) is estimated using ordinary least squares (OLS). As a novelty, the variables that make up block B4 (relevance of future changes) are introduced individually in order to capture new relationships. A multiplicative interaction term is also introduced between blocks 2 and 4. The results confirm the previous conclusions: strong importance on the mode change of the redistribution centers, as well as the operational improvements. The positive moderating effect of digitization on modal shift, through the creation of redistribution centers, is also verified (interaction B2 and B3). In this case, it is confirmed that future changes in transportation (*Change_Inter*) can positively affect the use of intermodality, so we could not completely discard Hypothesis 5. The significance of *Change_Less* seems to verify, albeit slightly, that new changes in transportation (e.g., electrification) could negatively affect interest in transportation CO_2 emissions. In general, there is variability in the view of the effect of technological changes on modal shift, although there is no clear effect.

Table 5. OLS estimation. Dependent Variable B5-Modal Shift

Block /Variable	Estimate	standardized coefficients	t-student	Desv. Error
Intercept	-1.063		-1.220	0.871
B1: Operational improvements	0.302**	0.257	2.198	0.137
B2: Communication and planning	0.177	0.164	1.290	0.137
B3: Redistribution Centers	0.326***	0.335	2.688	0.121
B2 x B3	0.252*	0.428	1.924	0.090
Change_Inter	0.222**	0.257	2.123	0.105
Change_Ectr	-0.100	-0.116	-0.949	0.105
Change_Less	0.211*	0.201	1.700	0.124

R^2= 0.623; R^2 Adj=0.522; F=9,869***; Breusch-Pagan test=0.839 (p=0.360)

Significant for p<0.01; ** Significant for p<0.05Significant for p<0.01; * Significant for p<0.1

7. Conclusions

A modal shift from road transport to intermodality using SSS is a complex problem which involves both operational variables and other, more strategic considerations. As for the former, there is a predisposition among horticultural commercialization companies to a modal shift, as long as it can ensure that the times, costs and quality at destination are the same as those of road transport. However, although intermodal lines significantly reduce many externalities, in general, they fail to match land transport in cost and transit time, which results in customer claims. In this light, and as the use of intermodality fails to "gain traction", it would be useful to find new options that help to promote the modal shift. In this sense, the creation of redistribution centers at destination, optimized by ICTs within a framework of digitalization of the entire chain stands out as a key factor. ICTs will have an impact on the coordination and simplification of all processes. For example, through coordination of communication between supplier-customer; cargo control (quality); traceability in real time; energy system optimization; implementation of Business Intelligence; and forecast improvements (Harris et al. 2015). These centers would provide important advantages: development of agile supply strategies, cargo groupage with different origins, and the reuse of returned products from complaints (Pérez-Mesa, 2022). In order to carry out this work, it will be essential to fight against the reluctance of companies to share information and collaborate (Colicchia et al. 2017).

What is more, from a more customer-oriented approach, although international logistics within the framework of a long supply chain and local and regional chains can appear to be incompatible, the creation of redistribution centers could help to redefine the concept of "short", in terms of logistics, as the process that optimizes the sustainability of the supply chain, as well as price and product variety available to customers. Another pending objective is to successfully coordinate the creation of a logistics platform at destination by marketing companies located in the production zones, thereby demonstrating to customers the proactive attitude of the supplier.

In this context, a modal shift will ultimately be the customer's decision, namely that of the large retail chains (Lidl, Edeka, Aldi, etc.). These companies have the power to impose their decisions upstream. On the other hand, these chains will try to "translate" consumer demands in terms of sustainability, including transport. We must remember that, over the years, commercialization companies have been losing their logistical capabilities – leaving them in the hands of the buyer. At present, in-house logistics management fails to reach 30%. Therefore, commercialization organizations must make it a priority to become essential and agile within the supply chain they share with customers and other horizontal suppliers. In short, we can conclude that a redistribution center could not be created without considering intermodality in transport. However, the latter is rather difficult to envision without progress being made in the centralization of production at destination, supported by the digitalization of the chain that helps to coordinate suppliers and customers.

As for the limitations of the present study, one problem with the proposed approach is the need for cargo groupage to guarantee operators a profitable minimum volume. This situation constitutes a problematic step due to the perishable nature of the goods, which require swift transit. Also, in the long term, greater volumes can lead to better prices, direct routes, higher frequency and even the availability of faster ships with which to reduce transit times; causing redistribution centers to lose some of their advantages. To conclude, it is necessary to comment that this article seeks to promote the discussion on the need to incorporate a more strategic vision in the analysis of the need for modal shift – one strongly focused on operational and technical aspects. In this sense, there remains a wide field of future study concerning the promotion of intermodality, seeking out options and tools for collaboration in the supply chain, for example, by applying new business models (Stal et al., 2022).

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Annex 1. Non-parametric correlation: Rho de Spearman

	Mean	Desv	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
1.Time	3.44	1.33	1	.465**	.350**	0.146	-0.191	0.236	.358**	0.231	.344*	.360**	0.205	-0.062	-0.262	.362**	0.2
2. Quality	4.00	1.36	.465**	1	.410**	.285*	-0.235	.459**	.368**	0.114	.289*	0.256	.278*	-0.11	-0.203	.498**	.421**
3. Environm	3.98	1.38	.350**	.410**	1	.532**	-0.011	.383**	.327*	0.062	0.113	0.099	.347**	0.034	-0.193	0.246	.356**
4. Cost	4.95	1.24	0.146	.285*	.532**	1	0.014	0.208	.320*	0.234	0.183	.280*	.490**	.289*	0.157	.362**	.321*
5. Cost_Time	5.07	1.41	-0.191	-0.235	-0.011	0.014	1	-0.109	-0.119	0.053	-0.069	-0.18	-0.029	.382**	.304*	-.329*	-0.134
6. Comun_Inter	4.75	1.40	0.236	.459**	.383**	0.208	-0.109	1	.707**	.395**	.495**	.439**	.324*	-0.121	-0.252	.423**	.477**
7. Comu_Quali	4.85	1.27	.358**	.368**	.327*	.320*	-0.119	.707**	1	.529**	.474**	.532**	.363**	0.005	-0.058	.536**	.497**
8. Comu_Cost	4.69	1.20	0.231	0.114	0.062	0.234	0.053	.395**	.529**	1	.322*	.320*	0.249	.351**	0.185	.392**	.326*
9. Center_Serv	4.80	1.24	.344*	.289*	0.113	0.183	-0.069	.495**	.474**	.322*	1	.735**	0.236	0.028	-0.236	.463**	.351**
10. Center_Compla	4.71	1.30	.360**	0.256	0.099	.280*	-0.18	.439**	.532**	.320*	.735**	1	.312*	0.046	-0.081	.615**	.453**
11. Change_Inter	4.24	1.33	0.205	.278*	.347**	.490**	-0.029	.324*	.363**	0.249	0.236	.312*	1	.394**	0.063	.321*	.479**
12. Change_Elec	4.84	1.34	-0.062	-0.11	0.034	.289*	.382**	-0.121	0.005	.351**	0.028	0.046	.394**	1	.576**	0.024	0.095
13.Change_Less	4.78	1.10	-0.262	-0.203	-0.193	0.157	.304*	-0.252	-0.058	0.185	-0.236	-0.081	0.063	.576**	1	-0.046	0.078
14. Accept	3.96	1.26	.362**	.498**	0.246	.362**	-.329*	.423**	.536**	.392**	.463**	.615**	.321*	0.024	-0.046	1	.686**
15. Import	4.11	1.26	0.2	.421**	.356**	.321*	-0.134	.477**	.497**	.326*	.351**	.453**	.479**	0.095	0.078	.686**	1

**Significant for p<0.01; * Significant for p<0.05

Annex 2. Pearson's parametric correlation

	Mean	Desv	*B1*	*B2*	*B3*	*B4*	*B5*
B1	4.09	0.98	1	.431**	.406**	0.123	.541**
B2	4.76	1.07	.431**	1	.392*	0.147	.553**
B3	4.75	1.19	.406**	.392*	1	0.075	.585**
B4	4.62	0.91	0.123	0.147	0.075	1	.279*
B5	4.04	1.15	.541**	.553**	.585**	.279*	1

**Significant for p<0.01; * Significant for p<0.05