The last chance for intermodal strategies for redistribution of vegetables from Southeast Spain

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Abstract

European Administration has spent years trying to shift traffic from the road to the sea, using intermodality in order to achieve a modal rebalancing. This study analyses new approaches that strengthen the modal shift, rather than focusing simply on the reduction of externalities. A possible option is to redefine ports, conceptualising them as redistribution and coordination centres and not only as areas of cargo exchange. The present article analyses this problem by attempting to promote intermodality (truck and short sea shipping) for the transport of highly perishable products (vegetables) exported from Southeast Spain, which is the leading supplier to Europe. The location of coordination centres between customer-provider is analysed by applying a p-median multicriteria model, adapted to the transport of perishables. This scheme avoids bias in decision-making processes.

Keywords: *Agile response time, Digitalisation, Retailer, Transport, Supply chain.*

1. Introduction

Despite the efforts made to promote Short Sea Shipping (SSS) in merchandise transport, the demand for this service as an integral part of a logistics network is still well below that of road transport (European Commission, 2017). Several research works have shown that operators have a clear preference towards land transport (Raza *et al.*, 2020). These studies point out several reasons for this preference: SSS has a bad image in the door-to-door transport chain; embarkation procedures require documentation which is not standardised among different ports or countries; port infrastructure often represents a limiting factor; there is a lack of information and monitoring of the cargo during transit; and the service provided tends to be slow and infrequent. Although intermodal transport using SSS is usually cheaper than by road, transit times are longer. This point is crucial when transporting perishable products, where product quality can be adversely affected. In any case, this variable is also influenced by the frequency and number of passages. It is possible that as the willingness to use intermodal shipping increases, the frequency of boats per week would increase as well, thereby reducing the time difference between intermodal and land transport. It is important to note that these problems do not occur only in intermodality for perishables with the use of SSS (Rossi *et al.*, 2021).

As a positive aspect, the literature finds that maritime transport is more sustainable than road

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transport (Gonzalez Aregall *et al*., 2018; Vallejo-Pinto *et al*., 2019. In this sense, it is clear that deep-sea shipping services are less polluting, but in the case of short see shipping (SSS) this comparative advantage is not so evident (see Hjelle, 2014). For example, considering Greenhouse Gas emissions per ton-km, SSS is not always preferable to road transport (Kotowska, 2016). Nonetheless, SSS is still considered an interesting alternative to be promoted as a step towards sustainable logistics chains (Pérez Mesa *et al.*, 2021).

Among the strategies of The European Commission to reduce greenhouse gas emissions by 2050 is to shift 30% of road freight transport over short distances to alternative modes (European Commission, 2011; European Commission, 2016). In this sense, SSS and motorways of the sea (MoS) are good tools. SSS and MoS, using Roll on-Roll off (Ro-Ro) short sea shipping services, are equivalent concepts. Both systems refer to the movement of cargo and passengers by sea between ports situated on a coastline of the seas in Europe or bordering Europe (European Commission, 2016). However, this definition does not clarify what type of goods must be transported. For Douet and Cappuccilli (2011), MoS may, or may not, be useful depending on the type of product, for example perishable or non-perishable. Therefore, it might make sense to use only MoS for goods where delivery time is not "vital".

In short, the European Commission believes shifting traffic from the road to the sea will be positive for the environment and society as a whole by mitigating negative externalities, such as congestion, pollution, or traffic accidents. Despite all efforts, however, shippers remain reluctant to shift traffic from the road to the sea (Paixão Casaca *et al*., 2010), and very little success has been achieved since the publication of the First White Paper on Transport (European Commission, 2001). Nevertheless, over time, the European Commission still expects to reconfigure maritime intermodal logistics by promoting a more sustainable transport model than roads can offer (European Commission, 2018). It is expected that improvement of frequency and quality to offer a door-to-door service at similar cost conditions to the truck alternative will be the key to MoS's success (Lupi *et al*., 2017; Paixão Casaca *et al*., 2010), more so in perishable goods (Pérez Mesa *et al*., 2012).

Within this framework, the aims of this paper are several. The most important is the identification and assessment of alternative transportation strategies, based in the intermodality, for F&V exported from Southern Spain to EU: the present study analyses whether SSS is applicable to the case of perishable goods. The empirical analysis will be applied to the exportation of fruit & vegetables (F&V) from Southeast Spain (Almeria, Murcia and Granada) to Europe. This region is the leading vegetable supplier to the European Union (EU), as well as the United Kingdom. Nearly 40% of vegetables consumed in the EU come from Southeast Spain. In 2020, this region exported more than 6 million tons of vegetables to the EU at a value of 5.7 billion euros (Eurostat, 2021). The key intermediary customers are large distribution chains (Aldi, Carrefour, Lidl, Edeka, Rewe, Tesco, etc.). These clients buy 70% of all shipments. The cost of transport represents, on average, 30% of the price received by the exporter in the destination markets (Pérez Mesa *et al*., 2019), meaning lowering its cost would be a key competitive strategy, more so considering large competitors outside the EU, such as Morocco, are already using SSS to transport large amounts of vegetables from Tangier to ports in the south of the United Kingdom and northern Europe.

The study also analyses the possibility of establishing redistribution centres in the centre of Europe for perishable products, in this case F&V from Southeast Spain that are exported to the rest of Europe. The fact that 95% of current F&V transport is conducted via refrigerated trucks could be the key reason for implementing the European strategy for SSS (Pérez Mesa *et al*., 2019). The present work also attempts to identify whether the inclusion of environmental costs can favour the modal shift from "only road" transport to an intermodal system. This is important because shippers prefer profitability to environmental performance of transport (Lupi *et al*., 2017). In any case, great care must be taken when comparing the suitability of SSS versus road transport because in some cases external costs are not correctly internalised (Suárez-Alemán *et al*., 2016), for example, by not considering the costs of infrastructure involved.

In general, the estimated total external costs for road transport per tonne and kilometre are higher compared to SSS (García Menéndez & Feo-Valero, 2009), but sometimes this depends on the chosen route (Vierth *et al*., 2019).

Methodologically, this paper seeks to contribute to the literature by proposing a different and complementary approach to establish a comparison between SSS and the "only road" alternative. For this purpose, the multicriteria decision is utilised in a p-median model (P-M) adapted to a means of shipping selection problem which must consider different variables: transit cost (including externalities), time and frequency (including agile response time). Some works have addressed intermodal selection based on modified p-median models. For example, Teye *et al*. (2017) proposed a probabilistic approach for locating competitive multi-user facilities in a maritime transportation system when complete information is not available for decision makers by using a bi-level model that incorporates the weighting of new variables (Abareshi & Zaferanieh, 2019). The multicriteria decision is another way to address this problem from a much simpler point of view.

2. Redistribution centres and its integration into a general perishable's transport strategy using SSS

Several works demonstrate that integrating redistribution or consolidation centres into perishable supply chains benefits suppliers and customers in several ways (Orjuela-Castro *et al.*, 2017; Caracciolo, 2018; Martins *et al.*, 2018; Pal & Kant, 2018). However, a few studies address the benefits related to the international distribution of this type of product (Pérez Mesa *et al.*, 2021). Some of the issues they analyse are detailed below.

1. Merchandise can be returned to the supplier for a variety of reasons. In such cases, the products would be disposed of due to the impossibility of returning them to origin. As an alternative, by utilising this new model, products could be repackaged and served again to customers. It is estimated that 10% of exports are returned by customers due to minor defects. In economic terms, for Southeast Spain, this represents more than 550 million euros in losses for exporters. In the case of the new strategy, response time to customers would be reduced, as a portion of the repackaged produce would be served from the redistribution centre rather than from origin. In other words, a product that would otherwise be wasted could be sold again.
2. It is important for suppliers to maintain a strategy of fast and agile (flexible) service. Suppliers could store produce in advance near the final demand and, based on their estimates, serve customers throughout Europe as they receive orders. As a result, response times to customers' orders (transit times) would be reduced by separating, albeit by a few days, transport to the logistics centre and the final shipment to the customer. Consequently, both service and customer loyalty would be improved. Also, this strategy could also have positive consequences on the reduction of waste, both in marketing companies at origin and at retail points of sale.
3. Large retailers (e.g., Aldi, Lidl, Rewe, Edeka, Carrefour or Tesco) with points of sale throughout Europe would want to have a distribution centre supplied by a priority origin (Southeast Spain in our case). This strategy would be framed within intensive supplier-customer collaboration in an ad hoc supply chain that is easier to implement. Although, in fact, there is a coordination system with buyer-driven supply chain dominance, especially in safety standards (Malorgio *et al.*, 2016).
4. This system constitutes a proactive strategy by suppliers, generating more stable relationships with customers. It must be noted that at present most shipping is organised by the customer. Additionally, this strategy can improve capacity to attract local/regional small retailers that require a more continuous service. What is more, vegetables from a long supply chain can be sold as "short chain" or "proximity".

In this context, the fundamental idea proposed is to integrate SSS and MoS into a global strategy for the redistribution of perishables in Europe, which takes into account the reality of current supply chains that promote collaboration and logistical coordination between suppliers and customers (Cholez *et al.*, 2021). If properly managed, these redistribution centres could result in key advantages for all members in the supply chain: reduced delivery times, inverse logistics and improvement of flexibility and service quality and reliability. Digitalisation would become the key transversal focus at these centres, as it would serve to optimise all processes (Martins *et al.*, 2018). More specifically, the aim is to study the use of European ports on the Atlantic and Mediterranean coasts so they may serve as consolidation and redistribution centres of F&V that can generate an agile response to customer demands, integrating into the new trends towards short food supply chain (Enjolras & Aubert, 2018).

In practical terms, it is assumed that loads of F&V are to be transported from the port of Almería (Southern Spain) by means of an intermodal system making use of short sea shipping (SSS). The produce can be transported by ship from the port of Almería to various destination ports (along the Atlantic and Mediterranean); from there it is to be transported by road directly to the end customers. The opposite alternative consists exclusively of road transport from the origin port to the final customer. The present work will seek to determine the optimal routes in order to minimise transit cost (including external cost), time and frequency. Figure 1 illustrates the objective of this work and the integration of SSS into this strategy. The selected destination ports along the Atlantic coast are Southampton, Hamburg and Dunkirk; along the Mediterranean coast Marseille and Livorno. These destinations were agreed upon by logistics experts for having storage potential for perishable products. In fact, there have already been shipping trials from Southeast Spain to some of these ports, as in the case of Almeria to Dunkirk and Southampton. The final unloading destinations (specific cities) were obtained from interviews with logistics managers of horticultural commercialisation companies.[1] Unloading figures were calculated from the total exported volume of F&V from Almeria, Murcia, and Granada (Spanish Customs, 2020), distributed among the final destinations (unloading cities per country) identified by the experts, who also provided approximate % of unloading per city.

Note that the key elements in any intermodal transport system are the intermodal terminals (IMTs) and their geographical locations with respect to cargo origins and destinations (Salucci, 2006). The level of user benefits or attractiveness of the new means of transport critically also depends on where the IMT is located with respect to the cargo origins and destinations.

From a transversal perspective, this strategy would require a "refinement" of cross-docking procedures, e.g., the use of multifold transportation processes, temporary inventories or combining with other merchandise. In this sense,

Figure 1 - Intermodal transport strategy proposed for vegetable products from Southeast Spain. Metric tonnes transported.

Black = Origin of the merchandise; Grey = Unloading areas and transported volume (final customer); Arrows = Examples of intermodal routes; Crosses = Ports chosen as redistribution centres.

[1] Special thanks are given to the Organization of Fruit and Vegetable Producers of Andalusia (APROA, www.aproa.eu).

Table 1 - Logistics benefits of the digitalisation of the supply chain and its relationship with creating redistribution centres.

Tactical and operational improvements	*Strategic improvements*
• *Coordination of communication between supplier-customer*: real-time exchange of information that favours shipment planning and the selection of transport system. • *Capacity control*: Know the status of incoming cargo so it may be distributed to the means of transport without any delays. • *Route optimization*: Optimise the route and transport system in the most effective manner. • *Cargo control*: Be aware of any eventuality in real time, which favours communication with the customer to react with sufficient time to any setbacks. • *Traceability in real time*: Systems capable of following not only the vehicle or shipments, but also each item individually. • *Energy optimisation*: filtering of routes and intermodal systems according to effective energy consumption between origin and destination (optimisation of carbon footprint). • *Implementation of Business Intelligence systems* for the improvement of management (development of Data Cubes for each agent). • *Forecast improvements* related to supply (variable in agrifood sector) and demand. Such forecasts would lead to reductions in waste and losses.	• *Facilitate the creation of intelligent distribution centres at destination*: better coordination between supply and demand facilitate the exchange and consolidation of cargo at destination, making feasible the creation of redistribution centres at destination. The tactical and operational improvement can be more readily implemented. • *Development of stable logistics relationships between supplier and customer* based on intelligent information exchange strategies. Basis for differentiation in relation to the competition. • *Improvement of the logistics efficiency and sustainability* of the supply chain.

Source: Own elaboration.

the use of ports can be optimal. Nevertheless, supply chain digitalisation would have to be implemented. Digitalisation represents one of the key points for the development of redistribution centres due to the opportunities for coordination that it offers (Martins *et al.*, 2018).

More specifically, the digitalisation of logistics management implies the use of different methodologies, technologies and tools (Anke, 2017): i) the development of ad hoc software for tracking and product selection to bring production closer to the consumer, ii) the application of the Internet of Things (IoT) to facilitate multiple processes, for example, traceability, control and optimisation of transport, or access to real-time information so management can make decisions (Ben-Daya *et al.*, 2019); iii) the accumulation of disaggregated information with Big Data tools and its immediate availability to management (cloud computing) to be later interpreted by Business Intelligence applications; and, iv) the application of other technologies, such as Blockchain, to facilitate documentation exchange and expedite administrative procedures, or even recognise patterns (neuronal networks) with the objective of predicting supply (variable) and demand, common in the agrifood sector. As can be seen, these aspects could easily be taken advantage of at intermodal redistribution centres (Table 1).

3. Methodology

3.1. *Classic P-Median problem*

The distribution and location family of problems encompasses formulations varying in complexity from simple single commodity linear deterministic models to multi-commodity nonlinear stochastic versions (Farahani *et al.*, 2010). The techniques applied can be used for all types of facility location models including: single facility location, multiple facility location, quadratic assignment problems, location–allocation, covering problems, p-median problems, p-centre problems, hierarchical facility location problem, hub lo-cation problems, competitive facility location, warehouse location problems, dynamic facility location problems, location inventory, location-routing, location reliability and, in recent times, location in supply chain using a mix of different approaches (Zheng *et al.*, 2019). The problem with p-medians (P-M) is locating p facilities in a network, minimising the sum of all costs or distances from a demand point to the nearest facility, while respecting its full capacity. This problem has been widely addressed in the literature, namely, the seminal works of Hakimi (1964). The general formulation implies:

$$Min \sum_i \sum_j h_i \, d_{ij} Y_{ij} \quad [1]$$

s.t.:

$$\sum_j Y_{ij} = 1 \quad \forall i \quad [2]$$

$$\sum_j X_j = p \quad [3]$$

$$Y_{ij} - X_j \leq 0 \;\; \forall i, j \quad [4]$$

$$X_j = 0, 1 \;\; \forall j \, ; Y_{ij} = 0, 1 \quad \forall i, j \quad [5]$$

Where Yij is 1 if customer i is served by facility j, 0 if not; hi is demand at location i; dij is cost/distance from location i to location j; p is the number of facilities to be located. The objective function [1] minimises the demand-weighted distance between each demand node and the nearest facility. Xj is 1 if a facility is located at candidate site j, 0 if not. The first constraint [2] ensures that each demand node will be allocated to one and only one facility. The second constraint [3] sets the number of facilities to open to exactly p. The next constraint [4] prevents demand from being allocated to candidate sites that do not have facilities. The last constraint ensures that Xi and Yij have Boolean values of 0 or 1.

All the models proposed in this paper were solved using PuLP, which is a modeler written in Python. PuLP has quite a few choices of solver algorithms (e.g., COIN_MP, Gurobi, CPLEX, etc.). For this problem, we do not specify any choice and let the program default to its own choice depending on the problem structure. Access to the software programmed for this paper is provided in the Google Collaboratory environment.

3.2. *Multi-criteria optimisation within the P-M problem*

The proposed models utilise land distance, travelled by truck, as a reference variable. However, it may be worthwhile to include other decision factors that introduce the possibility of a modal shift in the modelling. The two most important variables that condition the selection of a perishables transport system are time and cost (Pérez Mesa *et al.*, 2019), which is why they will be introduced in a multi-criteria optimisation approach within the P-M.

In short, this paper seeks to maximise a utility function as follows:

$$U = \sum_p^n w_p \;\; f_p(x),$$

where $f_s(x)$ is the mathematical expression of the p-th attribute and w_p is the weight or pondering that the decision maker gives to that attribute. More specifically, the present study utilises weighted goal programming, which is a widely-used multi-criteria solution method in the literature (Ching-Ter *et al.*, 2014; Antunes & Henriques, 2016). The function applied and adapted to the case of analysis can be found in Annex 1.

3.3. *Transportation cost function*

For intermodal costs, the calculations begin with a matrix c^I for unitary costs per lorry, derived from transporting the merchandise from each destination port to the customer's door and from the place of origin to the end customer (by truck). It is worth noting that introducing a type of non-linear cost function could be desirable considering the increase in cargoes that pass through a specific port could in turn increase the competitiveness of the logistics operators and reduce the unitary cost of maritime transport. However, from an environmental point of view, it is also shown that the higher the load factor of the ship, the wider the geographical scope for which the SSS is preferable (Vallejo-Pinto *et al.*, 2019). For these reasons, it is necessary to create a model for these effects. In order to solve this problem, a potential function of maritime costs was designed (see Annex 1).

3.4. *Transit time function*

In this paper, total intermodal transit time (t_{ij}^I), in contrast to "only road" transport time (t_{ij}^L), will include two variables that are relevant to selecting between land and intermodal systems. The first is shipping time plus the last stage by road

(t_{ij}^{Is}), which refers to the duration of the transport between the port (or area) of origin and the destination port and final customer. The second is a variable designated as maximum wait time (t_{ij}^{Ie}), whose purpose is to consider the frequency (f) of the mode of transport in the analysis. In this way, for example, if the operator chooses land rather than intermodal transport, and knowing that lorries depart 7 times a week, the maximum wait time is equal to the number of total hours in a week (168 h) divided by the weekly frequency of the mode of transport (departures/week) t_{ij}^{Ie} = (168h/week)/f, which is 24 h. This figure represents the maximum number of hours that, in the worst case, an operator would have to wait to send their merchandise to the customer due to not being able to find an available lorry. With this formulation it can be concluded that $t_{ij}^{I} = t_{ij}^{Is} + t_{ij}^{Ie}$. In the present case, the frequency corresponds to a route taken four times per week, that is, t_{ij}^{Ie}= 42 hours. Note that it is possible that as the willingness to use intermodal shipping increases, the frequency of boats per week would increase as well, thereby reducing the time difference between intermodal and land transport (Pérez Mesa *et al.*, 2019). The new objective function can be found in Annex 1.

3.4.1. *Randomness of transit time*

Intermodal transit time (t_{ij}^{I}) is one of the critical variables of model [10] due to its randomness, owing to the existence of uncontrollable factors, for example, weather conditions or the state of a ship, which can affect its speed. It must be noted that this variability can affect both shipping time (t_{ij}^{Is}) and maximum wait time (t_{ij}^{Ie}). For this reason, we analyse how this might affect the results if we consider that $t^{I}(\xi)_{ij} \sim N(\varepsilon, \sigma^2)$.

The resolution algorithms for this type of problem are complex and depend on the type of distributions involved, whether random variables only appear in the objective function, only in the restrictions set, or in both (Chen *et al.*, 2011). In certain cases, the problem is notably simplified if the distribution of the random variables assumes a specific probability distribution (normal is the most common), as in the present case. Many researchers have extensively studied random path problems, such as Zockaie *et al.*, 2014; Sheng and Gao, 2016. Many of these models can have significant biases if there are not enough observational data. Our model seeks a deterministic equivalent of this stochastic problem in order to facilitate practical implementation. Using this type of model makes it possible to test the robustness of deterministic models with conditions of variability. The new objective function can be found in Annex 1.

3.4.2. *Attractiveness of redistribution centres for the customer thanks to agile response time*

At this point, we must consider how to incorporate the attractiveness of each redistribution centre for the customer. With this aim, a term is defined which specifies the probability that a customer residing at demand point *i* (demand located at node i) is served by facility *j*:

$$A_{ij} = \frac{u_{ij}}{\sum_j u_{ij}}$$

where u_{ij} is the utility of a facility located at node *j* for a customer originating at node *i*. This gravity p-median model (Drezner and Drezner, 2007; Drezner, 2014) assumes that $u_{ij} = \partial_{ij} t_{ij}^{-\lambda}$ where t = t_{ij}^{I} for intermodal transport or t_{ij}^{L} for "only road" transport; and ∂_{ij} denotes the attractiveness of facility *j* for customer *i* and λ denotes the parameter of the exponential time decay function. In other words, the utility measure decreases with time and increases with the attractiveness of a facility. The larger the value of lambda, the more attached the customer is to the nearest facility. In our case, we utilise $\lambda = 0.6$ to prioritise facilities near the customer as we are dealing with highly perishable products. In practical terms, priority is given to the most centrally located points (Carling *et al.*, 2015). The new objective function can be found in Annex 1.

3.5. *Data*

This paper examines Ro-Ro type transport vessels (speed of 18 knots, 145 TEUs[2]), so the

[2] Twenty-foot Equivalent Unit = 21,600 tons.

Figure 2 - Cost (€/TEU) of maritime transport between the port of Almería (South of Spain) and the port of destination.

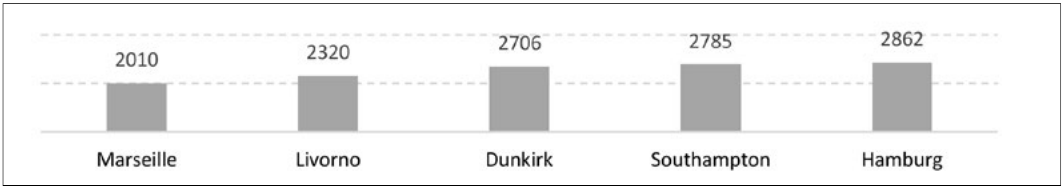


Figure 3 - Costs (€) for international transport refrigerated lorry.

maritime costs refer to the offer of a shipping company willing to provide the service plus the structural costs of leaving the platform of a trailer immobile for the duration of maritime transit. The port fees are the expenses derived from loading and unloading at the ports (origin and destination). In the present case, the offers proposed by the shipping companies are generic and include the port fees (offers received in December 2020). It is important to note that shipping lines do not exist. In order to obtain the price offers, a shipping broker located in the port of Almeria, was used. The researchers provided the destination ports, previously selected.

Figure 2 displays the transport costs of ad hoc lines with origin in Southern Spain and destination in Southampton, Hamburg, Dunkirk, Marseille and Livorno. These costs are roundtrip journeys. Upon return, it is considered that the containers are empty, which reflects current reality. In fact, maritime logistics have difficulties filling returning cargo, more so in the case of newly created lines.

The alternative is to transport the merchandise directly by road to the final customer. The data utilised are real. The cost (cL) corresponds to a refrigerated lorry for international transport and equal to 1.474 €/km (Spanish Ministry of Public Works and Transport, 2021), the distances (km) between ports and end customers were calculated using road guide software.[3] It is worth noting (Figure 3) that fuel costs only represent 29% of the total. It is also important to point out that tolls account for 8%.

In order to complete the analysis, it is necessary to include external costs derived from both maritime and ground transport: air pollution, costs derived from road congestion, noise, infrastructure wear and tear, costs from accidents and the emission of greenhouse gases. The present study followed the works of Denisis (2009), Álvarez Vivas (2012) and Vallejo-Pinto *et al.* (2019) in order to make the calculation. Said works establish costs per tonne and distance corresponding to land transport and Ro-Ro and Feeder (container) type maritime transport, similar to those used in this study. The summary of adapted data can be seen in Table 2. It must be noted that the inclusion of the externalities in road transport causes the former to increase by more than 35%. It is also important to ob-

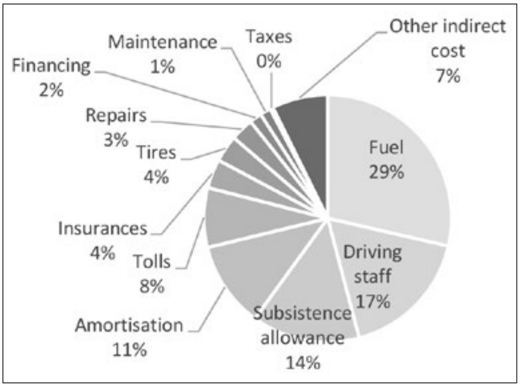
Table 2 - External costs of selected transport.

Concept	*Ro-Ro*	*Lorry*
Air pollution (1)	0.215	0.028
GHG (2)	0.001	0.002
Noise	0.000	0.290
Accidents	0.004	0.070
Congestion	0.007	0.046
Infrastructure	0.023	0.087
TOTAL (€/TEU/km)	0.249	0.522

(1) Emission of particulate matter, sulphur dioxide (SO_2), nitrogen oxide (NO_x), carbon monoxide (CO), volatic organic compounds.
(2) Emission of Greenhouses gases (CO_2). The calculations for (1) and (2) include all of the loading and unloading activities at the ports.
Source: Adaptation based on Denisis (2009), Álvarez Vivas (2012) and Vallejo-Pinto et al. (2019).

[3] To obtain the distance matrix more easily, software was programmed in Python, linking with Microsoft's Bing Maps API. Access in the Google Collaboratory environment.

Figure 3 - Costs (€) for international transport refrigerated lorry.



Source: Spanish Ministry of Public Works and Transport (2021).

serve that the concepts that favour SSS transport versus land are only those related to the maintenance of road and the indirect effects derived from road congestion. Emissions are higher in the case of Ro-Ro transport.

Annex 2 shows the costs (€/TEU) of transporting cargo from Southeast Spain to the three main exportation destinations via intermodal and only road, including externalities. The first feature that stands out is that even by including externalities there are routes, discarding the closest ones, where truck transport is cheaper and more sustainable, as in the cases of Stuttgart, Frankfurt, Lyon and Prague. The average savings cost of intermodal transport is 15%.

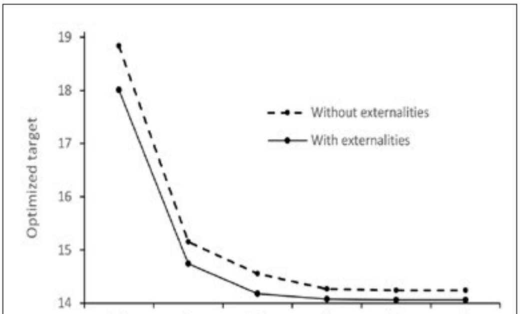
The time calculations utilised the average speed of 75 km/h and the legal driving times (only 9 hours per driver per day and obligatory breaks) and the matrix of distances obtained by the online land route manager (Microsoft Maps – Bing). The duration of the journeys by SSS between the port of Almeria (Southeast Spain) and Southampton, Hamburg, Dunkirk, Marseille and Livorno are 69, 76, 29, 41 and 94 hours, respectively. Sea transit times were provided by the logistics management (brokers) located in the port of Almeria, according to costs (and type of ship) also offered. Annex 3 displays the total times of both intermodal transport and "only road". The data show that the intermodal transport time is, on average, 2.3 times higher than "only road". Without question, this variable conditions the use of intermodality with perishable products.

4. Results and discussion

To begin, we must determine the number of facilities (p) that could be considered optimal. Figure 4 shows that with p>3 there is little improvement of the objective. The calculations are applied to the cost as it is the variable to which the externalities must be added. It can be deduced that p=3 can be considered the suitable number of distribution centres, more so if we consider the existence of destinations in remote areas of the European continent. Additionally, it can be observed that the introduction of environmental costs (externalities) improve the results 2.3%, on average. That is, this incorporation does not provide substantial improvements that can favour the modal change through the creation of redistribution centres at ports. Furthermore, it is shown that with p=3 the difference increases. Based on these results, it is determined that the suitable network which will continue to be studied herein will be defined by the existence of three ports or intermediate distribution centres.

Table 3 shows the results of all the proposed models ($p \leq 3$). If we consider a simple p-median model without cost correction, without including time as a decision variable, nor the externalities (O1), intermodality would represent 52% of transport. The inclusion of externalities

Figure 4 - Trade-off curve between target and P-facilities for w_c=1; α=0.2; θ=250,000t.



Source: Own elaboration.

Table 3 - Intermodal transport (truck+SSS) with and without externalities. Metric tonnes.

	O1	*O2*	*O3*	*O4*	*O5*	*O6*	*O7*	*O8*	*O7 agile*
Cases tested	w_c=1 $p \leq 3$	w_c=1 $\alpha = 0.5$ $\theta = 150{,}000t$ $p \leq 3$	w_c=1 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$	w_c=0.5 w_t=0.5 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42\ h$	w_c=0.7 w_t=0.3 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42\ h$	w_c=0.85 w_t=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42\ h$	w_c=0.85 w_t=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 56\ h$	w_c=0.85 w_t=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42h$ $\sigma = 150\%$*	w_c=0.85 w_t=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42h$
A) % Intermodal without externalities	52%	65%	45%	13%	23%	33%	33%	28%	63%
B) % Intermodal with externalities	63%	68%	57%	23%	37%	57%	45%	51%	63%
Load Tons A (x 1000)	2799	3498	2422	700	1238	1776	1776	1507	3510
Load Tons B (x 1000)	3391	3660	3068	1238	1991	3068	2422	2745	3510

(*) ε = average shipments years 2018-2020; φ = 95%.

improves the results by 11 percentage points. The incorporation of economies of scale causes the results to vary for the most part, depending on the threshold (small thresholds (O2) would favour the modal shift, with respect to the base model, while the opposite would occur with higher thresholds (O3).

These results reveal the strong variability that can exist depending on the improvements in cargo groupage, the incorporation of better adapted ships or even the optimisation of coordination between customer and supplier, all of which with the aim of reducing unit costs. The decision to include the time variable in the models (O4 to O6) causes a "radical" drop in the expectations for intermodality. To return to the same results of model (O2), the weights must be wc=0.85 wt=0.15, in other terms, the decision maker must value the cost more than fivefold in relation to the transit time. For equal weights between cost and time (O4), intermodality would represent 23%. These results demonstrate that intermodality, despite the inclusion of time, can be an option, albeit to a small extent, for specific routes. It is also found that the simplification of the decision models can result in considerable bias in the results.

In parallel, we also test the increase in maximum wait times (O7), revealing a considerable reduction in intermodality. Undoubtedly, the existence of greater frequencies is a key variable to be considered if there is any desire for a modal change. The random times model (O8) demonstrates the robustness of the results of the deterministic model: such high variability as that incorporated (σ = 150%) barely changes the results.

In general, it is observed that the consideration of transit time annuls the advantages in costs that can generate externalities for the modal change. It must be highlighted that the incorporation of the capacity of a flexible service for the customer considerably improves intermodal use (up to 63%). Indirectly, the (O6) agile model supports the simple (O6) model, thereby justifying its validity.

Delving deeper into the composition of the network, including externalities (Table 4), it can be observed that in all the models where only cost is included as the decision variable (O1-O3), the key redistribution centres would be located in Hamburg and Dunkirk. In other words, the Atlantic coast would be the primary option. Important destinations located in the United Kingdom and the Netherlands and central Europe would be supplied through Dunkirk, while northern Germany and the most eastern areas of Europe would be supplied by Hamburg. It must be highlighted that, for the most part, the largest customers located in France would prefer the use of trucks.

When including time in the weighted models (O4 and O5), the option of the port of Marseille, on the Mediterranean coast, would be the preferred choice for supplying isolated destinations.

Table 4 - Intermodal transport routes (truck+SSS) and "only road" with externalities.

Using port or only road:									
	O1	*O2*	*O3*	*O4*	*O5*	*O6*	*O7*	*O8*	*O6 agile*
Cases tested / Final destinations:	w_c=1 $p \leq 3$	w_c=1 $\alpha = 0.5$ $\theta = 150{,}000t$ $p \leq 3$	w_c=1 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$	w_c=0.5 w_t=0.5 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42\ h$	w_c=0.7 w_t=0.3 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42\ h$	w_c=0.85 w_t=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42\ h$	w_c=0.85 w_t=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 56\ h$	w_c=0.85 w_t=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42h$ $\sigma = 150\%$*	w_c=0.85 w_t=0.15 $\alpha = 0.2$ $\theta = 250{,}000t$ $p \leq 3$ $t_{ij}^{Ie} = 42h$
Hamburg	Hamburg	Hamburg	Hamburg	Road	Hamburg	Hamburg	Hamburg	Hamburg	Hamburg
Stuttgart	Road	Dunkirk	Dunkirk	Road	Marseilles	Dunkirk	Road	Marseilles	Dunkirk
Berlin	Hamburg	Hamburg	Hamburg	Road	Road	Hamburg	Hamburg	Hamburg	Hamburg
Cologne	Dunkirk	Dunkirk	Road	Road	Road	Road	Road	Road	Dunkirk
Frankfurt	Road	Road	Road	Road	Road	Road	Road	Road	Dunkirk
Perpignan	Road	Road	Road	Road	Road	Road	Road	Road	Road
Paris	Road	Dunkirk	Dunkirk	Road	Road	Dunkirk	Road	Marsella	Dunkirk
Lyon	Road	Road	Road	Road	Road	Road	Road	Road	Road
Barendrecht	Dunkirk	Dunkirk	Dunkirk	Marseilles	Marseilles	Dunkirk	Dunkirk	Marseilles	Dunkirk
London	Dunkirk	Dunkirk	Dunkirk	Marseilles	Marseilles	Dunkirk	Dunkirk	Marseilles	Dunkirk
Glasgow	Dunkirk	Dunkirk	Dunkirk	Road	Road	Dunkirk	Dunkirk	Road	Dunkirk
Dublin	Dunkirk	Dunkirk	Dunkirk	Road	Road	Dunkirk	Dunkirk	Road	Dunkirk
Milan	Road	Road	Road	Road	Road	Road	Road	Road	Road
Rome	Road	Road	Road	Road	Road	Road	Road	Road	Road
Brussels	Dunkirk	Dunkirk	Road	Road	Road	Road	Road	Road	Dunkirk
Warsaw	Hamburg	Hamburg	Hamburg	Road	Road	Hamburg	Hamburg	Hamburg	Hamburg
Prague	Road	Hamburg	Road	Road	Road	Road	Road	Road	Road
Vienna	Road	Hamburg	Road	Road	Road	Road	Road	Road	Road
Stockholm	Hamburg	Hamburg	Road	Road	Road	Road	Road	Road	Road
Copenhagen	Hamburg	Road	Road	Road	Road	Road	Road	Road	Road
Helsinki	Hamburg	Road	Road	Road	Road	Road	Road	Road	Road
Lisbon	Road	Road	Road	Road	Road	Road	Road	Road	Road
Athens	Road	Road	Road	Road	Road	Road	Road	Road	Road
% Intermodal	63%	68%	57%	23%	37%	57%	45%	51%	65%
% Only Road	37%	32%	43%	77%	63%	43%	55%	49%	35%
Interm. Road Kms (hours)**	426 (6.2)	514 (7.5)	509 (7.5)	1204 (17.7)	1115 (16.4)	534 (7.8)	543 (7.9)	896 (13.2)	474 (6.9)

(*) ε = average shipments years 2018-2020; φ = 95%.
(**) =Average of the last road section (kms / hours) in intermodality ("agile response time").

As the cost variable becomes more relevant (models O6 and O7), Dunkirk is again preferred over Mediterranean ports. It should be noted that intermodality in the use of perishables requires the decision maker to value cost nearly six times more than transit time. It is also observed that intermodality is suitable for areas with certain proximity to redistribution centres (coastal areas) on the Atlantic coast and which generate loading capacities that can create economies of scale. A paradigmatic case is that of Brussels, which, despite its proximity to Dunkirk, would be better to supply by road. Of course, its location is on the borderline between intermodality and road and could surely be absorbed by the Durkirk hub with slight improvements to the intermodal logistics management, which is similar to the case of Cologne (in Germany). It is worth noting that models O1 and O2 provide for these changes, as does agile model O6. By introducing variability in transit time (O8), Marseille would be the key centre on the Mediterranean coast as this port combines the advantage of cost and customer response time in situations of uncer-

Figure 5 - Possible intermodal strategy (O6 agile). Metric tonnes transported.

Light Grey = Transport by road; Medium Grey = Intermodal centre using Hamburg; Dark Grey = Intermodal centre using Dunkirk.

tainty regarding sea transit time; this port boasts the shortest shipping time, which compensates for a longer road transit.

Agile model O6 incorporates Cologne, Frankfurt and Brussels into the Dunkirk hub, and as expected, improves response time. It is important to highlight that the redistribution centreoptions (excluding Marseille) have a response time of around six hours in the final stage by road. This detail is fundamental for providing the customer with optimum service, a key element for implementing redistribution centres. This system would also make it easier for returned products to be repackaged and resold.

Figure 5 shows the agile O6 strategy, which is a feasible extension of the O3 and O6 strategies and, thus, is one of the options with the highest prospects of success. Undoubtedly, the collaboration of merchandise suppliers, logistics services companies and customers (large European retailers), aided by the possibilities of coordination generated by the digitalisation of the supply chain, could produce synergies that would facilitate the modal shift, thereby further expanding the action radius of the selected redistribution centres. It is important to highlight that model (O8), even with longer response times, is a robust system that would minimise the risks derived from the longest SSS transit times, meaning it should not be discarded either.

5. Conclusions

The European Commission has not been successful in its efforts to shift traffic from the road to the sea using intermodality. The shippers still remain reluctant. It is time to seek new approaches. Objectively speaking, traditional transport logistics suffer from very significant deficiencies. A reason for this is the lack of cooperation and coordination among logistics companies, but also among marketing companies regarding groupage of shipments. Another factor is the complexity of ensuring empty trucks (in the upon turn), which is further complicated by perishability. Raising the efficiency of perishable transport and distribution is a very complex issue that becomes even more difficult when dealing with mixed commodity types (Pal & Kant, 2018).

Recent trends towards preferences for regionally grown food place further stress on regional, low volume distribution (local logistics) and complicate its integration with long-distance logistics, which is traditionally high volume and uses refrigerated transport. In fact, it is tempting to forego expensive refrigerated transportation for local logistics. In contrast, this article argues that international transport using intermodality can be a good option if it is integrated into specific business strategies, such as the creation of real distribution centres at ports or nearby locations. Moreover, the development of logistics networks is a fundamental point for the commercial maintenance of peripheral areas in the Mediterranean (Kendi *et al.*, 2020).

The main benefits of SSS compared to road transport are: i) cost savings (around 15%); and ii) reduction of externalities (around 35%). Undoubtedly, the critical point is the increase in transit times: 2.3 times higher than “only road”. However, utilising the multicriteria decision within an adapted p-median model (P-M) for intermodality to be an ideal option, the cost variable (including externalities) must be valued by the exporter six times higher than transit time – a factor which affects quality, increases returns due to damage, etc. In a recent survey conducted among horticultural exporters (Pérez Mesa *et al.*, 2021), the most important decision variable, in nearly 37% of all cases, was that "the shipment is made in the shortest possible time". It is clear that perishability is the fundamental factor preventing modal shift. The difficulty of implementing intermodality leads us to consider whether to grant priority to road transit for the transport of perishable products and the use of SSS for other less delicate ones.

In general, the results reveal that, in the case of perishables and under normal circumstances, intermodality would be a secondary and viable option only for very specific destinations, for example, Hamburg and nearby locations, the area of influence of London, Paris and the Netherlands. In this regard, the Netherlands represents a special case, as it is an area of reexportation of similar products from, for example, north Africa. Thus, this last option should be avoided as it would not favour the differentiation of European products. Nonetheless, there are additional drawbacks.

As discussed above, the influence of externalities as a driver of modal shift "vanishes" when transit time is introduced as a decision variable. These results confirm that general strategies, e.g. those used by the European Commission, based on the benefits of intermodality to reduce transport externalities, lose their enforceability when applied to complex circumstances. We therefore considered whether the European strategy of applying SSS indiscriminately is the right approach. Subsequently, we proceeded to introduce several scenarios for transit time, including its randomness, as it is the key variable for modal shift. Note that we also reveal the robustness of deterministic models. This contribution is therefore a novelty in the sense that this paper infers that simplifying decision models, avoiding models or eliminating transport determinants can lead to considerable bias in the results.

The study also shows that by introducing the concept of agile response time (i.e., the time needed to deliver an urgent order from the redistribution centre to the customer), the intermodal option improves. In this sense, this article argues that international transport using intermodality can be a good option if it is integrated into specific business strategies, such as the creation of real distribution centres in ports or nearby locations, close to final consumers. Through these redistribution centres, F&V exports would be integrated into the new trends towards short food supply chain. These redistribution centres would offer important advantages: reduction of delivery times, inverse logistics, cost optimisation, flexibility and service quality and reliability, and improvements, when applicable, to order preparation and shipment. Moreover, the development of logistics networks is a key point for the commercial sustainability of peripheral areas of the Mediterranean (Kendi *et al.*, 2020).

In summary, perhaps the government should promote specific business strategies based on new trends in the supply chain (not only on the reduction of externalities) and find new approaches that strengthen the modal shift. A possible option is to redefine ports, conceptualising them as digitalised redistribution and coordination centres and not only as areas of cargo exchange. This entire strategy would not be viable without close coordination between the horticultural exporter, the customer (large European retailers) and the logistics service provider. In this regard, the digitalisation of logistics management should be a priority (Anke, 2017) as it would facilitate and "fine tune" the coordination of all the actors involved. As a further limitation, other operational aspects related to the management of redistribution centres are not addressed in this work. Without question, these issues deserve more in-depth research in future studies, specifically for the case of perishables.

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Annex 1 - Methodological annex

1. *Multi-criteria optimisation within the P-M problem*

The problem that arises from a practical point of view is:

$$Max \sum_p^n \frac{w_p}{K_p} f_p(x) \quad \text{Subject to F} \in \text{x; x} \geq 0 \qquad [a1]$$

Where F is the set of restrictions utilised and K_p is a factor of standardisation. To provide a sense of fairness between each objective function, it is necessary to normalise using root mean square, so $K_p = \sqrt{E\left[f_p(x)\right]^2}$. In the standardisation method, the minimising function is marked negative, while the maximising function is marked positive.

Applying formulation [a1], the new equation [1] would take the following form:

$$Min \sum_p \sum_i \sum_j \frac{w_p}{K_p} h_i \, d_{pij} Y_{ij} \qquad [a2]$$

Where, in our case, $d_{p=1}$ is the intermodal transport cost (c^I) or land transport cost (c^L) and $d_{p=2}$ is the intermodal transport time (t^I) or land transport time (t^L). Organising [a2] for this specific analysis, we have:

$$Min \sum_i \sum_j \frac{w_c}{K_c} (c_{ij}^I + c_{ij}^L) h_i Y_{ij} + \sum_i \sum_j \frac{w_t}{K_t} (t_{ij}^I + t_{ij}^L) h_i Y_{ij} \qquad [a3]$$

s.t.: [2] to [5]

Where $\frac{w_c}{K_c}$ and $\frac{w_t}{K_{ct}}$ will be the standardised weights for transit cost and time, respectively.

2. *Transport cost*

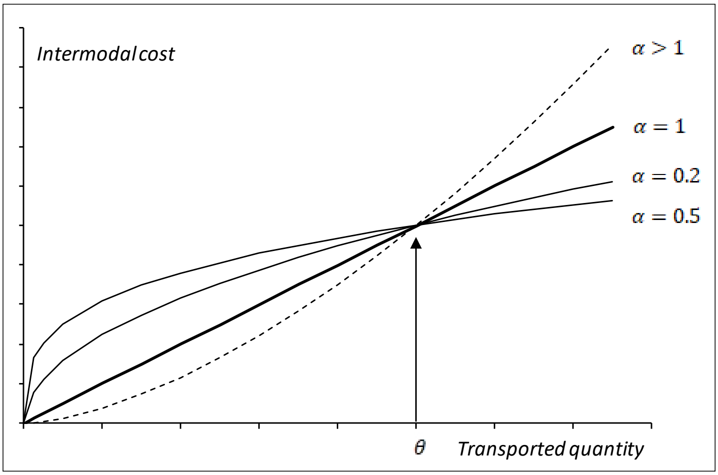
To simulated the effect that the existence of decreasing scale costs has on the distribution of routes, a function is incorporated which provides for the drop in costs according to the volume transported: $\theta_i^{(1-\alpha)} h_i^{\alpha}$. It must be noted that it is assumed the greater the volume transported, the greater the average size of the ships will also be. The formulation of the p-median problem [a3] will now be:

$$Min\ \sum_i \sum_j \frac{w_c}{K_c} [c_{ij}^I \theta_i^{(1-\alpha)} h_i^{\alpha} Y_{ij} + c_{ij}^L h_i Y_{ij}] + \sum_i \sum_j \frac{w_t}{K_t} [(t_{ij}^I + t_{ij}^L) h_i Y_{ij}] \qquad [a4]$$

s.t.: [2] to [5]

Where θ will be the tonnage at which economies of scale begin to appear that affect both internal and external (environmental) costs. This value, therefore, can be understood as the cargo threshold (Figure a1). Specification [a4] was thus designed to facilitate the comparison between the differences produced in the distribution of merchandise as a consequence of cost fluctuation resulting from increases in cargoes. Taking the existence of economies of scale as a starting point, the value of α must be inferior to the unit, since it determines the elasticity of the maritime costs in relation to the increase in production. We take α >1 and θ = average volume transported for all destinations. Also tested were α = 0.5 and θ = 150,000 t.

Figure a1 - Potential costs function for Intermodal transport.



3. *Transit time*

The new objective function which will need to be minimised is now:

$$T(c,t) = \sum_i \sum_j \frac{w_c}{K_c} [c_{ij}^I \theta_i^{(1-\alpha)} h_i^{\alpha} Y_{ij} + c_{ij}^L h_i Y_{ij}] + \sum_i \sum_j \frac{w_t}{K_t} [(t_{ij}^{Is} + t_{ij}^{Ie}) h_i Y_{ij} + t_{ij}^L h_i Y_{ij}] \qquad [a5]$$

3.1. *Randomness of transit time*

We now encounter a new function: $T[c, t^I(\xi)]$ To build a new model with non-precision variables, Charnes & Cooper (1959) propose a chance-constrained model. So, the new p-median model will be:

$$Min\ T(c,t) \qquad [a6]$$

s. t.

$prob\{T[c,t^I(\xi)] \leq T\ (c,t)\} \geq \varphi$

[2] to [5]

The following can be done to convert an uncertain chance-constrained programming model [a5] into a deterministic model (Huiru *et al*., 2015): first, $T[c,t^{Is}(\xi)]$ is an uncertain regular variable, so its distribution function and inverse distribution functions are ψ, ψ^{-1}, respectively. In terms of a given confidence level (φ), we can find a number $T(\varphi)$ that satisfies

$$prob\{T[c,t^{Is}(\xi)] \leq T(\varphi)\} = \varphi.$$

Also, we can deduce that $T(\varphi) = \psi^{-1}(\varphi)$, where:

$$\psi^{-1}(\varphi) = \sum_i \sum_j \frac{w_c}{K_c}[c_{ij}^I \theta_i^{(1-\alpha)} h_i^\alpha Y_{ij} + c_{ij}^L h_i Y_{ij}] + \sum_i \sum_j \frac{w_t}{K_t}[\phi_{ij}^{-1}(\varphi)] h_i Y_{ij} + t_{ij}^L h_i Y_{ij}]$$

being $\phi_{ij}^{-1}(\varphi) = \varepsilon + \frac{\sigma\sqrt{3}}{\pi} ln\ (\frac{\varphi}{1-\varphi})$; that is, the inverse of the normal distribution of $t^I(\xi)_{ij}$.

The p-median model [a5] is now redefined in a deterministic form as:

$$Min\ T(c,t) \qquad [a7]$$

s. t.

$\psi^{-1}(\varphi) \leq T\ (c,t)$

[2] to [5]

In our model, we solve model [12] for σ = 150 % over the value of the median (a high value to test at the limit) and taking ε = average shipments for years 2018-2020, also φ = 95%.

3.2. *Attractiveness of redistribution centres for the customer using agile response time*

The new objective function based on [a4] would become:

$$T(c,t) = \sum_i \sum_j \frac{w_c}{K_c}[c_{ij}^I \theta_i^{(1-\alpha)} h_i^\alpha Y_{ij} + c_{ij}^L h_i Y_{ij}] + \sum_i \sum_j \frac{w_t}{K_t} A_{ij} h_i Y_{ij} \qquad [a8]$$

To build ∂_{ij} included in A_{ij}, an index is calculated according to the agile response time (t_{ij}^r), that is, the minimum hours needed to supply an express order from the redistribution centre to the customer:

$$\partial_{ij} = \frac{t_{ij}^r - min\ (t_{ij}^r)}{max(t_{ij}^r) - min\ (t_{ij}^r)}$$

In the intermodal case, t_{ij}^r will be the time of the final stage by road. In other words, it is supposed that the product is already present at the redistribution centre. In the case of road transport, the total transit from the origin is considered, diminishing the attractiveness of this option. It should be noted that the decision is made by the supplier and customer jointly, which means the weight system remains valid.

Annex 2 - Transport cost (€/TEU) from Southern Spain using intermodal transport and "only road" with externalities

Using port:						
Cases tested / Final destinations:	*Southampton*	*Dunkirk*	*Marseille*	*Livorno*	*Hamburg*	*Truck*
Hamburg	5599	4868	5256	5747	3753	5194
Stuttgart	5597	4866	4160	4544	5058	4096
Berlin	5936	5205	5352	5516	4314	5289
Cologne	4934	4203	4358	5182	4599	4295
Frankfurt	5287	4558	4288	4859	4735	4224
Perpignan	5964	5724	2923	4626	6996	1958
Paris	4325	4049	3835	5111	5555	3645
Lyon	5239	4977	2913	4222	6106	2850
Barendrecht	4682	3952	4623	5604	4765	4499
London	3774	3874	4759	6001	5595	4549
Glasgow	4888	5131	6017	7258	6853	5477
Dublin	4758	5049	5935	7177	6771	5347
Milan	6134	5574	3320	3530	5966	3531
Rome	7287	6730	4081	3298	7074	4293
Bruxelles	4485	3754	4324	5350	4931	4247
Warsaw	7012	6281	6330	6067	5454	6265
Prague	6305	5574	5073	5131	5034	5010
Vienna	6696	5965	4997	4745	5689	5210
Stockholm	7537	6806	7194	7602	5705	7132
Copenhagen	6247	5516	5905	6312	4416	5842
Helsinki	8491	7762	8150	8248	6661	8086
Lisbon	7491	7498	5599	7302	9004	1745
Athens	10018	9287	6633	5803	8992	6844

Annex 3 - Transport time (hours) from Southern Spain using intermodal transport and "only road"

Using port:						
Cases tested / Final destinations:	*Southampton*	*Dunkerque*	*Marsella*	*Livorno*	*Hamburgo*	*Truck*
Hamburg	129	131	97	110	136	46
Stuttgart	129	131	88	99	148	36
Berlin	132	134	98	108	141	47
Cologne	124	125	89	105	144	38
Frankfurt	127	128	89	102	145	38
Perpignan	133	138	77	100	165	17
Paris	118	123	85	104	152	32
Lyon	126	132	77	97	157	25
Barendrecht	121	123	92	109	145	40
London	113	122	93	112	152	40
Glasgow	123	133	104	123	164	49
Dublin	122	132	103	123	163	48
Milan	134	137	80	90	156	31
Rome	144	147	87	88	166	38
Bruxelles	120	121	89	107	146	38
Warsaw	142	143	107	113	151	56
Prague	136	137	96	105	147	45
Vienna	139	140	95	101	153	46
Stockholm	147	148	115	127	153	63
Copenhagen	135	136	103	115	142	52
Helsinki	155	156	123	132	162	72
Lisbon	146	154	100	124	183	15
Athens	169	170	110	111	183	61