Revista de Economía Aplicada E A *Número 57 (vol. XIX), 2011, págs. 65 a 95*

DEMAND ANALYSIS FOR ALTERNATIVE SEA TRANSPORT SERVICES: APPLICATION OF DISCRETE CHOICE MODELS TO THE AGRIFOOD EXPORTERS*

JUAN CARLOS PÉREZ MESA
EMILIO GALDEANO GÓMEZ
Universidad de Almería

This paper analyses the potential demand for sea transport services for agrifood exports to European countries. The approach of the study is based on the random utility and the application of discrete choice models to two alternative transports: land and sea. The empirical analysis takes as its reference the possibility of increasing shipping of food products from Southeast Spain to Southeast France. By estimations of Binomial and Mixed Logit, heterogeneity of preferences is determined, showing that the decision of exporters depends mainly on costs and time of transit. These estimations lead us to consider different scenarios and to analyze the sensitivity of final clients to future change in the variables which condition the choice between the two forms of transport.

Key words: land and sea transport, logistic.

JEL Classification: F14, L91, R42.

European transport policies aim to prioritise sustainability. As such, there is a concerted effort to integrate rail and sea traffic of merchandise into intermodal transport systems, while simultaneously alleviating road congestion [Sakalys and Palsaitis (2006)]. The European Union [EU, Transport White Book 2001–2010)] makes several references to the promotion of sea transport, particularly the so-called short-sea shipping[1]. It points out the need to foment alternatives to road transport, highlighting short-sea shipping due to its technological and environmental efficiency and because it has a capacity which, it

(*) This research was partially funded by Spanish MCINN and FEDER aid ECO2008-02258, ECO2008-03445 and Redymar Project (P10/08) Spanish Ministry of Development (MFOM).

(1) In this context, the concept of “motorways of the sea” is also introduced as a wider notion of sea transport [González and Novo (2007)].

appears, will not be congested in the foreseeable future [Marchese and Musso (2002)]. In this line, some objectives are outlined: i) better connections between ports and river and rail networks; ii) improved quality of port services. Sea transport must be integrated into transeuropean transport networks such as railways, motorways or airports. They should offer port to port transport whose cost and quality level allow the service to reach a level of competitiveness comparable to that offered by land transport [González and Novo (2007)].

Despite considerable effort in recent years to foment sea transport, no great progress has been made to achieve the EU's aim for 2010 of a rebalance of the overall transport pattern. Another important EU initiative in this area deals with the assurance of fair and efficient pricing for all modes. The European Commission opts for the internalization of external costs in order to produce a gradual increase in road transport costs, thus, rendering coastal shipping and other alternative modes more competitive [Kapros and Panou (2007)]. However, over recent years, the public sector has invested considerably in road and rail infrastructure throughout the EU, while maritime transport has not received the same degree of support. It is argued that the seaway-equivalent infrastructure of roadways and railways is the deck of a ship. Analysis of sea motorways demonstrates the substantial modal shift that can be achieved by innovative carriers using advanced ship technology supported by appropriate public policies [Baird (2007)]. Although EU policy is based on the expansion of ports and connections with inland areas [European Commission (2008)], it neglects support measures for services, operating costs and advertising.

Various research projects and other initiatives have identified a number of issues that contribute to an apparent preference amongst cargo shippers and consignees for land-based modes of transport where such alternatives are available [Marchese and Musso (2002); Napier University (2002)]. These include a poor image of sea transport in the door-to-door transport chain, low standardization and multiple documentation procedures, constraints arising from port infrastructure and management, lack of information and control regarding cargo in transit, and slow and infrequent services [Paixao and Marlow (2001a)]. Although the drawbacks are many, sea transport also features some very positive points. These include geographical, financial, energy and environmental advantages, as well as an underused capacity for expansion and positive effects on ancillary activities which create employment and economic growth [Paixao and Marlow (2001b); Tongzon and Sawant, (2007)].

The present work aims to analyze potential demand for sea transport as an alternative to land transport of agrifood exports to EU countries. Over recent decades, the modelling of transport demand has been based on the theory of random utility [McFadden (1974)]. The Multinomial Logit [McFadden (1974, 1981)] and, more recently, the Mixed Logit [Ben-Akiva and Bolduc (1996); Brownstone and Train (1999)] are among the models most frequently used. The former allows systematic variations in preferences for means of transport to be recorded, while the latter also covers the unobserved heterogeneity in these preferences.

Our empirical analysis applies both models using a survey of preferences of agrifood exporters from Southeast Spain (provinces of Almería, Granada and

Murcia). It considers exporting products which are finally destined for countries in Central Europe by sea from the port of Almería[2] to Port Vendres-Perpignan (Southeast France)[3]. This case study is of interest for several reasons. First, it has been referenced at institutional level in several applied projects [Vidal (2007); García and Vallejo (2003); Salinas and Palao (2006); Salinas and Bayo (2008)], and it represents a demand of exporters from Southeast Spain, bearing in mind the outlying nature of this area in the overall European context [Pérez-Mesa and De Pablo (2007); Salinas and Palao (2006)]. Second, despite European policies to promote sea transport, little research has been carried out to date on this question [Baird (2004, 2007)].

Unlike other studies on transport demand [e.g. Guirao *et al*. (1995); Train (1998); Morey and Rossman (2002); Morera and González (2005)] which contemplate surveys for the users of different forms of transport, the present work analyzes demand potential for sea transport. Thus, several forecasts on the alternative of this mode of transport are elaborated with a view to considering changes in the variables of the demand models. Different scenarios are created for the market shares of the alternative forms of transport contemplated by the study.

The study aims to contribute to the body of literature on discrete choice models applied to transport demand and particularly, to consider projects of intermodal transport in the context of EU policy [Baird (2004); Vidal (2007)]. Furthermore, although technical characteristics have been considered as well as the economic and strategic aspects of a case study [Baird (2007)], the results of the study are intended to provide information on certain aspects and problems to which special attention should be paid in future applications which may have some points in common with the case analyzed here, e.g. exports sector, peripheral location, absence of alternatives to the transport service used, and so on.

The paper is structured as follows. Section 1 reviews the theoretical issues and describes the methodology followed. Section 2 outlines the application and the different scenarios considered. Section 3 shows the estimations and results and Section 4 outlines the conclusions.

(2) Almería is the main Spanish province for exports of horticultural produce (tomato, pepper, cucumber, zucchini and eggplant). Murcia excedes Almería only in exports of lettuce. For instance, for tomato, Almería accounts for over 54% of Spanish exports [FEPEX (2008)]. Which is much more sensitive to transport than fruit (citrics, for example). It is logical to suppose that the port of despatch will be the one closest to the area of production (i.e. the port of Almería), which is trying to create an area of influence for the produce of Murcia and Granada [Salinas and Palao (2006)].

(3) The Pyrenees frontier is reaching crisis point as regards road transport and most of the merchandise (such as fruit and vegetables) destined for Central European countries passes through Perpignan [Barnard, (2004)].

1. Methods

1.1. Theoretical foundations and econometric models

Most discrete election models are based on the random utility theory [Domencich and MacFadden (1975); Ben-Akiva and Lerman, (1985)] which postulates that an individual q associates with each alternative i a stochastic type of utility (U_{iq}), choosing the alternative which maximizes utility. The impossibility for the analyst to appreciate all the attributes and variations in preferences which influence the individual's behaviour, as well as measurement errors, make it necessary to consider that utility is the sum of two differentiated components:

$$U_{iq} = V_{iq} + \varepsilon_{iq} \qquad [1]$$

where V_{iq} is a component which is a function of the measurable attributes[4] and ε_{iq} is a random or stochastic component, which reflects everything that the researcher is unable to measure, allowing apparent irregularities to be explained. The expression which is adopted for the deterministic component of utility is often a linear function in the attributes and parameters, as follows:

$$V_{iq} = \sum_{k=1}^{K} \beta_{ik} x_{ikq} \qquad [2]$$

where x_{ikq} is the value which the k-th attribute takes for the individual or demander q and β_{ik} is the parameter linked to that attribute, which is considered constant for all individuals even though it may vary among alternatives.

The traditional way to record the heterogeneity of preferences has been to introduce interactions among the attributes of the alternatives and the socioeconomic characteristics of the users or demanders [e.g. Train (1998); Morey and Rossman (2002)]. Thus, the parameter of each attribute β_{ik} is a function of the socioeconomic characteristics observed. This method only allows the systematic variation of preferences to be detected.

However, there is often no information available on an individual level or the preferences vary according to characteristics which are difficult to measure or even unobservable. In these cases, to consider heterogeneity we can specify random parameters in the indirect utility function. Thus, the utility i for each demander q is expressed as:

$$V_{iq} = \beta_q x_{ikq} = (\beta + \mu_q) x_{ikq} \qquad [3]$$

where β_q is now a vector of unobserved coefficients for each demander q which varies randomly according to their preferences and can be expressed as the sum of

(4) The utility function used in transport demand models has traditionally included the duration of the journey, its cost and the income of the user, among others as explanatory variables. The considerations as to the relevant variables are based on pioneering works such as those of Train and MacFadden (1978).

the populational average (β) and the individual deviations with respect to the average preferences of the population (μ_q).

The drawback of specifying random parameters is that no information is provided as to the determining factors of the variation in individual preferences, so it may be of interest to use a specification which contains both interactions and random parameters.

Whatever the approach adopted to record the heterogeneity of preferences, we assume that the key factor for the decision is the maximization of utility, in such a way that the demander *q* chooses alternative *i* whenever the utility of this alternative is greater than that associated with any of the remaining ones *j*, both of which belong to a set of alternatives which are available to the demander *q* (*A(q)*):

$$U_{iq} \geq U_{jq} \,,\; \forall j \in A(q) \;, i \neq j \qquad [4]$$

that is,

$$V_{iq} + \varepsilon_{iq} \geq V_{jq} + \varepsilon_{jq} \Rightarrow V_{iq} - V_{jq} \geq \varepsilon_{jq} - \varepsilon_{iq} \qquad [5]$$

As the analyst does not know ($\varepsilon_{jq} - \varepsilon_{iq}$), it is impossible to say whether expression [5] is fulfilled or not and, therefore, only the likelihood of its occurrence can be considered. Thus, the probability of choosing alternative *i* is given by:

$$P_{iq} = \text{Prob} \;\left\{\varepsilon_{jq} \leq \varepsilon_{jq} + (V_{iq} - V_{jq}), \forall j \in A(q)\right\} \qquad [6]$$

which is equivalent to:

$$P_{iq} = \int f(\varepsilon) \cdot d\varepsilon \qquad [7]$$

In this way, the residues, ε, are random variables with zero average, which will give rise to different probabilistic models depending on the statistical distribution considered.

1.2. Empirical discrete choice models

The most widely used distributions for residues, ε, are Extreme Generalized Value, which gives rise to Logit-type models, and Normal which gives rise to Probit-type models. In recent years, the so-called Mixed Logit models, considered as an alternative to the two above mentioned ones, have been widely adopted in studies of transport demand [for greater details see, for example, McFadden and Train, (2000)]. Several authors [e.g. Brownstone and Train (1999); McFadden and Train, (2000)] consider that the Mixed Logit model has the same flexibility as the Probit, while maintaining the simplicity of the Logit.

When considering a model with systematic variation of preferences where the error term, ε, follows an identical and independent Gumbel distribution, we obtain the so-called Multinomial Logit or simple Logit [McFaden (1974)]. Furthermore when considering a model with random variation of preferences and the same distribution for the unobserved component of utility, the Mixed Logit-type specification is obtained or that of random parameters where the utility of alternative i is given by the following expression:

$$U_{iq} = (\beta + \mu_q)x_{iq} + \varepsilon_{iq} = \beta x_{iq} + \mu_q x_{iq} + \varepsilon_{iq} \qquad [8]$$

This expression is a particular case of the most general expression of a Mixed Logit model, usually represented as:

$$U_{iq} = V_{iq} + \eta_{iq} + \varepsilon_{iq} \qquad [9]$$

where $\varepsilon_{iq} \sim$ Gumbel $(0, \sigma^2)$ and $\eta_{iq} \sim f(\eta/\theta)$, in which f is a function of general density and θ the fixed parameters which characterize its distribution across the population.

As ε follows an identical and independent Gumbel distribution, the likelihood that an individual q will choose alternative i conditioned to a value of η, will give rise to the Multinomial Logit model:

$$P_g\left(i/\eta\right) = L_{iq}(\eta) = \frac{\exp(V_{iq} + \eta_{iq})}{\sum_j \exp(V_{jq} + \eta_{jq})} \qquad [10]$$

Thus, the likelihood of choosing alternative i will be given by the integral, over all the possible values of η, of the conditioned likelihood given by equation [10] as follows:

$$P_{iq} = \int L_{iq}(\eta) f(\eta/\theta^*) d\eta \qquad [11]$$

It can be observed that the likelihood of choice is given by the formula of the Logit weighted by the function of density of η, integrated over all the values of η. This specification gives rise to the so-called Mixed Logit, which can take different forms depending on the function f which is considered. This model allows very general patterns of correlation and heteroscedasticity using a specification suited to the variables and the functions of density f of the different parameters [McFadden and Train (2000)][5].

For the specific case of random parameters, the likelihood of election would take the following form:

$$P_{iq} = \int \frac{\exp(\beta_{iq} + x_{iq})}{\sum_i \exp(\beta_{jq} + x_{jq})} \qquad [12]$$

In this case, the β are unknown and the unconditional likelihood is obtained by integrating over all the values of the populational distribution of β_q and multi-

(5) These authors show that, under certain conditions of regularity, any discrete choice model derived from a model of maximization of random utility has some choice probabilities that can be approximated as closely as desired by a Mixed Logit model.

plying each one by its function of density $f(\beta/\theta)$, where θ represents the parameters of this distribution (for example, if a normal distribution is considered, θ would represent the average and the covariance). With this, the parameters of the utility function (marginal utilities) are not fixed throughout the population but are random variables which follow a certain distribution of frequencies over the population f which the researcher defines *a priori*.

The probability P_{iq} of the Mixed Logit does not usually have a closed expression and, therefore, it is necessary to make a numerical approximation by simulation. R observations of β are extracted from the density function $f(\beta/\theta)$, they are weighted by the Logit probability and then averaged. The simulated probability (SP_q) would be this average. Thus, the simulated function of log-likelihood would be: $sl(\theta) = \sum_q \ln SP_q$.

By means of numerical processes of maximization, we can derive the estimators of θ, which define the distribution of frequency of the individual parameters β_q over the population by the method of maximum simulated likelihood [Train (1998, 2003)].

In this work, we apply a Binomial Logit and a Mixed Logit as discrete choice models with a view to characterizing both the systematic and the unobserved heterogeneity in the preferences of road and sea transport usage, in this case of agrifood exporters in Southeast Spain.

2. Application

2.1. Features of the case study: agrifood exports from Southeast Spain

The provinces of Almería, Granada and Murcia in Southeast Spain constitute a highly export-oriented zone, with a positive trade balance of 1,045 million euros (imports representing only 35% of exports). In economic terms, exports are concentrated in TARIC (the European Community's integrated tariff) chapters 07 and 08, that is, fruit and vegetables, which account for 82% of the value exported. The economic relevance of this trade has led to the consideration of maritime transport as a firm alternative to the transport of these goods by land [García and Vallejo (2003); Salinas and Bayo (2008)]. In particular, the rising cost of road transport (to date practically the only means of transport used) and the outlying location of this area in relation to the markets of destination mean that alternative forms of transport are of interest.

The main foreign destinations for agrifood products from Southeast Spain are (Table 1): Germany (26%), France (19%), Holland (15%) and the United Kingdom (11%). A traditional characteristic of this trade is that the wholesale market in Saint-Charles (Perpignan) and its area of influence, which includes the logistic centres of most of the French distribution chains (e.g. Carrefour), absorbs 70% of the exports from Southeast Spain to France. A sea transport service could help to integrate the export companies into the operations chain of the big French and European retailers [De Pablo *et al*. (2006)].

Perpignan has access to the sea via Port Vendres.[6] This port is the gateway to maritime traffic for fruit and vegetables from the north of Africa. In 2007, this port imported 210,000 tons of fruit and vegetables from the north of Africa (mostly from Morocco). From a strategic point of view, the establishment of a route from Almería to Port-Vendres could facilitate the coordination of Spanish and Moroccan exports of vegetables [Salinas and Bayo (2008)].

Table 1: EXPORTS (TONNES OF FRUIT AND VEGETABLES) FROM SOUTHEAST SPAIN

Province	Almería	Murcia	Granada
Germany	447,547	564,417	42,094
Austria	23,736	31,936	1,397
Belgium	47,79	39,463	4,63
Denmark	28,595	32,745	4,382
France	320,487	286,705	24,933
Italy	95,663	126,37	3,663
Netherlands	252,042	154,524	31,281
United Kingdom	184,998	452,204	31,044
Others	290,205	350,79	23,283
Total	1,691,063	2,039,154	166,707

Source: FEPEX (2008).

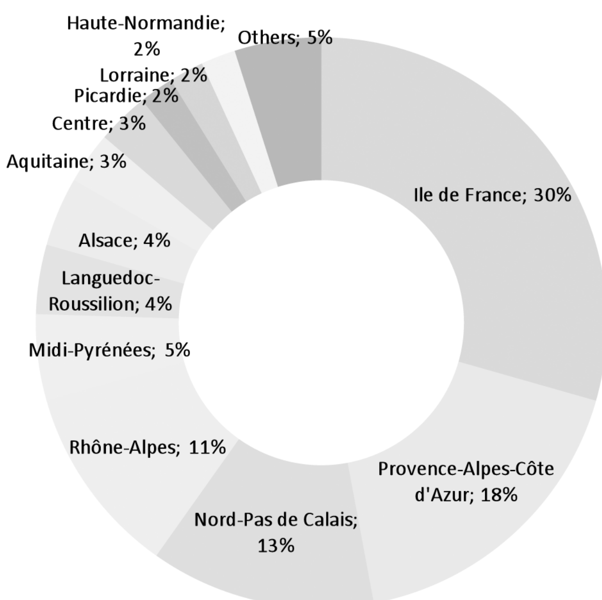
The current demand (metric tons) of exporters from Almería Port to Port Vendres is calculated in order to analyze the feasibility of sea transport, considering the agrifood production, mainly horticultural produce, represented by the provinces of Almería, Granada and also Murcia (see Table 1). This demand originates from the southeast of France (Perpignan) as well as from other areas which make use of transit through the French Mediterranean corridor and which must, therefore, pass through the reference area, i.e. Southern Germany, Italy and Austria.

In order to determine current land transport in this area and, by extension, the possible capacity for transport by sea via Port Vendres, we follow the recent study by [Salinas and Bayo (2008)]. The total volume is 435,000 tonnes that could theoretically be supplied via Port Vendres to satisfy the demand of:

(6) There are other reasons for choosing Port Vendres as the port of destination: i) the duration of maritime transit to Atlantic ports (Dunkirk or Rotterdam) can range between 75 and 100 hours; ii) the offers received for creating a line, for example to Dunkirk or Rotterdam, would imply a regularity of one departure every ten days (or two per week with three ships). These logistics imply a previous commitment of cargo which would be difficult to guarantee for the horticultural exporters, since yield varies greatly from one week to the next [Pérez-Mesa *et al*. (2009)].

– 70% of the French market (see Figure 1).
– 100% of the Italian and Austrian markets.
– 10% of the German market.

Figure 1: ESTIMATION OF FINAL CONSUMPTION OF FRUIT AND VEGETABLES IN EACH REGION OF FRANCE (%)



Source: Salinas and Bayo (2008).

By way of example, assuming a constant demand from the area of influence (435,000 tons from Almería, Granada and Murcia) with Perpignan as the final destination, the use of 50% maritime transport would mean an annual reduction in traffic of 10,885 trailers. Bearing in mind that almost all the transport of horticultural produce from this area (see last row of Table 1) crosses the Pyrenees to Europe, the same 50% use of maritime transport would mean an annual reduction in total traffic of over 97,400 trailers, i.e. 9% of total land transport of goods over the Pyrenees south to north, including that originating from Morocco and Portugal [Ministerio de Fomento (2007)].

2.2. Survey design and data

A questionnaire has been designed which will allow us to carry out an experiment of choice, as this is the best way to be able to predict the behaviour of possible users of sea or land transport, i.e. those who decide to use one or other service. These are, therefore, observations on revealed preferences which allow us to estimate discrete election models from which we can obtain demand elasticities regarding specific attributes (x) of the alternatives used. Based on the preliminary studies mentioned above [e.g. García and Vallejo (2003); Salinas and Palao (2006)], the attributes considered are:

- Ct = Cost of transport by road and by sea (€/kg).[7]
- T = Transit time in days: port-to-port transport in the case of land transport or port-to-door in the case of intermodal transport (sea-land).
- VU = Unit value of the merchandise in €/kg.
- RE = % of complaints at destination as a measure of transport quality[8].
- Fr = Frequency of transport.

The variable "kilometres to final destination" is not considered in the case of maritime transport, as delivery of the vast majority of produce is to Perpignan and the surrounding area.

Special attention is paid to the estimation of costs, the details of which are shown in Appendix "A". It should be noted that, whereas there are many references on the cost of road transport using refrigerated trucks, in the case of transport by sea it is necessary to calculate the cost of two alternatives in order to determine the average cost: "accompanied" transit (or Ro-Pax) and "unaccompained" transit (or Ro-Ro).[9] Technical characteristics, costs and timetables (Almería-Port Vendres) are described in Table A.1 in Appendix A.

A sample of 756 data has been used for the estimation, obtained from surveys to commercial agents and managers of horticultural exporting companies (see Appendix C for a summary of the general characteristics of these companies). Each of the attributes selected as useful has two levels, so the design implies representing 36 scenarios which are divided into two blocks (1 and 2). In other words, there are two different surveys, but each interviewee should only answer one with 16 different scenarios[10]. This is intended to prevent the interviewee

(7) For a study analyzing the determinants of maritime costs for Spanish exports, see Márquez *et al*. (2007).

(8) De Pablo and Pérez-Mesa (2005) analyze the cost leverage brought about by complaints at destination due to inferior quality.

(9) Bearing in mind these two main forms of sea transport, the possibility of using a "hierarchical" discrete choice model was also considered [e.g. Ortúzar and Willumsen (2001)]. However, insufficient knowledge of the technical characteristics of these two forms by most of the exporters included in the survey (without experience in sea transport) meant that an average cost was considered for sea transport. Nevertheless, both types of sea transport have been taken into account when proxying the different scenarios, as have the distance from the average cost or the spread in the Mixed Logit estimation.

(10) After a preliminary survey to indicate which firms were prepared to reply to the questionnaire, the firms were split into segments A and B, trying to maintain maximum homogeneity in both segments of firms to be interviewed, particularly regarding the number of employees and exports volume. For this purpose, the data supplied by the business associations were used to determine the average values of these variables for the potential sample, after which the two types of surveys were

becoming tired of making so many choices. The survey has been designed to avoid problems of multicolinearity, treating data econometrically. Special care has been taken to establish real levels for each of the attributes, carrying out a previous survey on operators from the horticultural sector in Southeast Spain. Generically speaking, the design of the questionnaire should count on additional current and future information on the variables (or attributes) used. The survey employs limit values (cost, transit time, etc.), which are the limits beyond which consumers clearly differentiate their preference for one or another form of transport.

Table 2 shows the results of the survey, revealing that for all the scenarios considered, 47% of responses on average are positive as regards the use of maritime transport. When maritime transport was accepted, 60% of responses chose the lowest cost, 53% chose the shortest time, 43% chose the lowest value good, 73% preferred fewer claims and 37% lower frequency. When road transport was the option chosen the results were similar.

Table 2: Summary of survey results

	Sea transport (47%)		Road transport (53%)	
	Lower value	Higher value	Lower value	Higher value
Costs (€/kg)	0.090	0.150	0.120	0.210
	60%	40%	59%	41%
Transit Time (hours)	30	45	12	18
	53%	47%	53%	47%
Good Unit Value (€/kg)	0.5	0.9	0.5	0.9
	43%	57%	44%	56%
% complaints	10	20	10	20
	73%	27%	76%	24%
Journeys /week	2	5	5	8
	37%	63%	59%	41%

Source: Own elaboration.

distributed proportionally among the firms that were above and below the average values. After the survey had been carried out, in order to check the homogeneity between the two groups, we used the Student's *t*-test (Welch) of equality of means. The results showed that the hypothesis of equality of means (H_0) can be accepted for the two variables indicated, i.e. the means of variables do not differ significantly between the two groups surveyed (A: 21 firms; B: 18 firms). The results obtained are the following: i) number of employees: t =1.3205 (p-value = 0.08891); ii) exports volume: t = 1.2615 (p-value = 0.09240). Prior to the t-test, the F-test (Fisher) was used to test the homogeneity of variances (H_0). The results showed the rejection of H_0 for the number of employees (F = 4.3527; p-value = 0.0278), but the acceptance of H_0 for the exports volume (F = 1.8046; p-value = 0.0609).

From the data obtained, by applying the above-mentioned discrete choice models, we aim to determine the heterogeneity of preferences for the mode of transport depending on the attributes considered. Using these models, particularly in the analysis of transport demand, different studies have shown that each individual or economic agent has different perceptions of utility, even for samples with very homogeneous characteristics. In our case, the companies in the sample show a series of common characteristics, such as the marketing of produce within the same category (fruit and vegetables), total or partial export activity to European countries and their geographical location, which means that they have similar transport requirements. Moreover, the survey asked about general socioeconomic data and did not find great differences in the number of employees, volume of exports or countries of final destination[11]. However, we should bear in mind other factors or components of heterogeneity among firms in the reference sector which are not observable from the surveys carried out but which may have a bearing on the choice of mode of transport. Several specific studies in this field highlight the following aspects: product specialization (since, within the fruit and vegetables sector, some firms have a specialized catalogue), the diversification of clients and the degree of consolidation in the market [see e.g. De Pablo *et al.* (2006)], the attitude towards taking risks with new forms of marketing[12] or differences in performance in exports activity within the sector [e.g. Galdeano-Gómez (2010)]. These aspects lead us to consider the existence of components of heterogeneity in preferences due to non-observable factors and, therefore, suggest the suitability of a model of random parameters to be estimated using a Mixed Logit.

3. Estimation and results

3.1. Model estimations

In order to characterize both the systematic and the unobserved heterogeneity in the preferences of usage of road and sea transport, a binary choice model is considered, taking into account the two above-mentioned methods, Logit and Mixed Logit.

The Binomial Logit is estimated in differences, according to the generic variables considered, following this specification:

$$\begin{aligned} V_{iq} - V_{jq} = \alpha_q + \beta_{Ct}(Ct_{iq} - Ct_{jq}) + \beta_T(T_{iq} - T_{jq}) + \beta_{VU}(VU_{iq} - VU_{jq}) + \\ + \beta_{RE}(RE_{iq} - RE_{jq}) + B_{Fr}(Fr_{iq} - Fr_{jq}) \end{aligned} \quad [13]$$

where i = land transport and j = sea transport.

(11) The firms in the survey have between 92 and 215 employees, and their volume of exports is between 29,000 and 61,000 tons. Nevertheless, in the initial tests of the empirical application, these aspects were included as specific variables and did not have significant parameters in the choice of transport mode. For economy of space, these preliminary analyses are not included in the present work, but they are available upon request.

(12) Many firms in the sector are associations or cooperatives and some studies have shown that they adopt different positions when faced with new market or economic risks, depending on the size of the cooperative members [e.g. Galdeano (2003); De Pablo and Pérez-Mesa (2004)].

On this model, a Box-Cox[13] type transformation was also proposed for the time variable (see Table 3), since, for perishable produce, the variation in utility as a result of time saving may well not be linear. However, no results were obtained to confirm this hypothesis. The existence of unobserved heterogeneity in the preferences was tested using the test specified by McFadden and Train (2000)[14]. The result of the test confirmed the existence of unobserved factors, which could explain the parameters of transit cost and time[15] (see also Table 3).

In accordance with the above results, the Mixed Logit is estimated, with random parameters for the differences in cost and time, using the following specification:

$$V_{iq} - V_{jq} = \alpha_q + [\beta_{Ct} + \eta_{Ct}(Ct_{iq} - Ct_{jq})] + [\beta_T + \eta_T(T_{iq} - T_{jq})] + \\ + \beta_{VU}(VU_{iq} - VU_{jq}) + \beta_{RE}(RE_{iq} - RE_{jq}) + B_{Fr}(Fr_{iq} - Fr_{jq}) \quad [14]$$

The estimated parameters of the two models, [13] and [14], are shown in Table 4. In the estimation of the Binomial Logit model, it can be observed that all the variables used are significant and show the correct sign. As expected, both cost and time appear with a negative sign, indicating how an increase in the cost and time of maritime transport (*ceteris paribus*) –or a fall in the cost and time of land transport– make the choice of sea transport less likely. The negative sign of the parameter of unit value indicates that an increase in this reduces the likelihood of choosing the maritime option; this may be because operators are not confident that quality can be maintained using sea transport, but are willing to take the risk with merchandise of lower value. This implies that if the production for transport from this area were specialised in goods of greater added value, the transport trend would favour road transport to the detriment of sea transport. Likewise, an increase in the % of complaints at destination in maritime transport (or a fall in complaints in land transport) makes the use of the sea system less likely. On the other hand, the positive sign of frequency explains how an increase in the frequency of vessels (for example, more than one a week) or a drop in the frequency of land transport, makes the choice of sea transport more likely.[16] This sign also

(13) According to, $x_i^{(\lambda)} = \dfrac{x_i^{\lambda} - 1}{\lambda}$ where λ take different values in order to optimize the likelihood function [Liem and Gaudry (1997)]. A logarithmic transformation was also tested, obtaining very similar results.

(14) The application of the test implies calculating some artificial variables from $z_{iq} = (x_{iq} - \overline{x_i})^2$ with, $\overline{x_i} = \sum_j x_{jq} \cdot P_{jq}$ where P_{jq} is the logit likelihood of choice. The logit model must be reestimated with the artificial variables. We reject the null hypothesis that the coefficient must not be random if the coefficient of the artificial variable is significantly different to zero. Brownstone (2001) points out that this test is easy to calculate, wide-ranging and powerful.

(15) The existence of unobserved factors that determine heterogeneity in these variables may reflect, as well as the heterogeneity expressed in the preferences of exporters, the effect of exogenous decisions taken by shipping firms regarding routes and frequency, in accordance with the overall strategy of these companies.

(16) This may be due to different factors, such as the need for better levels of customer service or the urgency to dispatch perishable goods.

Table 3: TESTS OF MODEL SPECIFICATION

	McFadden and Train test	Non-linear model
Constant	-3.583	0.231
	(0.356)	(0.825)
Ct	-65.118	-46.817
	(0.017)	(0.054)
T	-0.382	-0.193 [a]
	(0.021)	(0.151)
VU	-0.727	-0.619
	(0.091)	(0.521)
RE	-0.094	-0.108
	(0.640)	(0.000)
Fr	0.251	0.199
	(0.076)	(0.020)
Artificial Variables		
ZCt	-1241.465	–
	(0.026)	
ZT	0.102	–
	(0.041)	
ZVU	21.700	–
	(0.737)	
ZRE	0.014	–
	(0.550)	
ZFr	-0.018	–
	(0.771)	
Log likelihood	-127.403	-112.609
Wald test all artificial variables = 0	Chi = 9.1015	
	(0,1679)	
Observations	756	756

P- values in parentheses.

[a] A non-linear transformation of the Box-Cox type variable has been carried out using $\lambda = 0.6$, with maximum-likelihood procedure.

Source: Own elaboration.

indicates the existence of a latent demand for maritime transport. If there was a sufficient frequency and the routes were stable, there would be majority preference for this option. Indirectly, the frequency may be reflecting effects related to cost and, to a lesser extent, time, as greater frequency would mean lower costs as a result of improved negotiating ability with operators, which may also happen with transit time, for example, if we consider the option of using more modern ships for stable routes. For perishable produce, it can be observed that both an increase in the frequency of departure (*Fr*) and a reduction in transit time (*T*) would have a favourable effect on the demand for sea transport.

Table 4: ESTIMATIONS OF DISCRETE CHOICE MODELS

		Binomial Logit	Mixed Logit
Constant		-0.292	-0.327
		(0.810)	(0.841)
Ct	Media	-48.483	-49.051
		(0.011)	(0.018)
	Spread[a]	–	-31.220
			(0.024)
T	Media	-0.28	-0.291
		(0.003)	(0.008)
	Spread	–	-0.230
			(0.012)
VU		-0.935	-0.971
		(0.026)	(0.030)
RE		-0.116	-0.123
		(0.000)	(0.007)
Fr		0.202	0.194
		(0.001)	(0.004)
Log likelihood		-111.149	-110.987
Observations		756	756

P- values in parentheses.

[a] The spread (s) is the distance between the average (m) and the extreme of the interval in which the variable is distributed, so the interval is defined as [m-s, m+s].

Source: Own elaboration.

The estimation of the Mixed Logit model shows similar results and signs for the parameters considered in the Binomial Logit. For the specification of the random parameters, given that both parameters have a negative sign, they were considered to have a delimited distribution of Uniform or Triangular type, as the limits of distribution are estimated from the data[17]. The estimations of the Mixed

(17) In this way we avoid any bias in the form of distribution in favor of parameters with a sign contrary to the expected one, as occurs when normal distribution is assumed [see, for example, recent applications of Hess *et al*. (2005) and Amador and González (2005)].

Logit (Table 4)[18] show the results for specifications in which the parameters of transit cost and time vary randomly following a Uniform distribution. The parameters of the spread are significant in both cases, indicating that the preferences relative to transit cost and time vary according to unobserved factors.

This estimation, however, does not allow us to identify the relationship between the heterogeneity of preferences for means of transport and the characteristics of the exporting firms. Nevertheless, we can say that this result may be due to the existence of differences among firms, as some specific analyses of the sector (indicated above) have determined, which may represent an issue of interest for future research.

Be that as it may, the fact that this heterogeneity exists has led to the consideration of multiple scenarios in estimations on the evolution of transport demand, particularly related to the two variables which represent the greatest degree of randomness in preferences: cost and time.

3.3. Sensitivity analysis and scenarios

Table 5 shows a sensitivity analysis regarding the current situation of the variables used in the logit binomial model. The other variables remain constant. As expected, the results show that the variables with most potential for the shipping companies to influence the situation are cost and time of transit. It is also observed that a combined strategy of prices, quality[19] and reduction of transit time would bring about a 348% increase in market share compared to 2008. Modifying the cost and improving quality (improving maintenance of the produce) is a simpler strategy and would increase market share by 191%. Reducing price and transit time by 10% would increase the market share of sea transport by 259%.

Finally, different scenarios are established according to the variations which they might produce in the variables introduced into the estimated models[20]. We identified the possible scenarios, with situations that may exist in a particular year (we use a perspective for 2014 and 2020). This analysis should be seen as a mere simulation game. Due to the implications on transit cost and time, the scenarios

---

(18) The procedure used to carry out the extractions necessary for the simulation based on the distributions of parameters has been that of Halton's sequences. This procedure has proved to be more efficient than purely random extraction, reducing the number of extractions required to estimate the models and, therefore, also reducing the estimation time and/or the errors of simulation associated with a given number of extractions [Bhat (2000); Train (1999)]. In this study, the parameters have been estimated from 110 extractions of Halton using the GAUSS system [Train (2003)]. This code is available on the webpage of K. Train: http://elsa.Berkeley.EDU/~train/

(19) The quality of perishable produce may be determined by many factors which will have repercussions on the number of complaints. For instance, shipping of merchandise after a protracted period of storage in chambers (of the exporter) as a result of a delay in sales, or the existence of varieties that are less well adapted to transport. In addition, there may be negative effects of inappropriate handling during transport. In this context, quality strategies may vary, for instance: introducing ethylene absorbers into containers in order to improve fruit durability, using controlled atmosphere containers (control of CO_2), selecting more durable varieties or improving the coordination of orders between customer and supplier.

(20) Due to the space limitation, the simulation is presented using the coefficients obtained by the Binomial Logit because the simulation done with the Mixed Logit coefficients does not alter the conclusions.

Table 5: SENSITIVITY ANALYSIS

Sensitivity analysis: remaining constant variables	% Sea Market Share	% Land Market Share	% Increase in Sea Market Share
Current situation	1.12	98.88	
(1) 10% fall in the costs of sea transport	2.60	97.40	132
(2) 10% increase in prices of the produce usually dispatched by sea	0.18	99.82	-83
(3) Increase in the quality of sea dispatches, causing an average 10% reduction in complaints	1.79	98.21	60
(4) 10% decrease of transit time by sea	2.22	97.78	98
(5) 1 extra ship (double frequency)	2.12	97.88	90
(1)+(4)	4.01	95.99	259
(1)+(3)	3.26	96.74	191
(1)+(4)+(3)	5.01	94.99	348
(1)+(4)+(3)+(5)	7.32	92.68	559

Source: Own elaboration.

have been considered for the two types of sea transport described in Appendix A: Ro-Pax and Ro-Ro. This simulation implies, first, fixing the current value of the variables (cost, frequency, time, % of complaints) with a view to then deciding possible future scenarios. Table 6 provides a summary of the current costs of the different transport modes, grouping together the major cost factors (Appendix A provides further details of the disaggregated cost components and of how the unit costs per kilogram have been calculated). In order to calculate the evolution of the cost variable, we have applied a series of annual evolution ratios that have been taken as future scenarios (2014 and 2020) to the concepts which make up this variable (Tables A1 and A2 in Appendix A). With the exception of costs related to fuel, tolls and taxes, maintenance and repairs, all other costs increase at an annual rate of 2%. Fuel and tyres increase at an annual rate of 7%. Tolls, taxes and tariffs rise by 5% each year[21]. The cost concepts associated with maritime transport in-

(21) For these last two items, a higher rate of growth is considered, since several European countries intend to apply supplementary taxes on heavy goods transport (over 12 tons) by road. To this we should add different initiatives of eco-taxation, which offset the external transport costs [Schreyer *et al*. (2004)], and which may be applied to the final price of fuel. We should also add the positive tendential effects of the price of diesel fuel in the long term.

crease by 1% annually. This is because the progressive increase in maritime transport could be generating scale economies which bring about a fall in the costs incurred by shipping companies [Baird (2007)]. This means that the prices of the services they offer are maintained lower than those of land transport. Overall, higher growth rates have been applied to those concepts with more likelihood of future growth (e.g. fuel or tariffs). It is assumed that the concepts of sea transport costs will grow less due to the progressive increase in supply (competition).

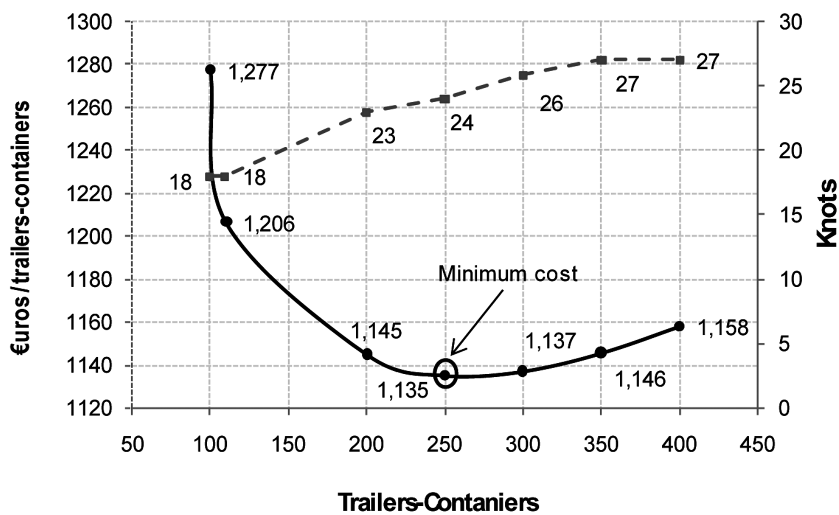
Also, two types of scenario have been established ("a" and "b"). Type "a" refers to more conservative situations. Type "b" scenarios refer to the use of values for the variables (complaints, transit time, and frequency) which favour change compared to type "a" scenarios. Costs are maintained constant for both types of scenario. The unit value variable is maintained constant over time[22] and also for scenarios "a" and "b". In short, the idea is to fix a series of values (a and b) for the years 2014 and 2020 under the assumption of improvements in the variables (% complaints, transit time and frequency) over time which favour the change of transport mode: i) increasing frequency (more so for type "a" than for type "b") as a result of market growth; ii) reductions in transit time (type "a" > "b") due to the incorporation of improvements in ships (for example, high-speed ships); and iii) reduction in the % of complaints (type "a" > "b") due to general technological improvements that affect quality. All the values calculated (for costs) and used (complaints, frequency, transit time and unit value) are shown in Table B1 in the Appendix.

The optimum result of scenarios "a" and "b" is also introduced, considering the optimum vessel to minimize the cost of sea transport. To this end, we have applied the optimization model developed by Ametller (2007), which relates the cost of a Ro-Ro vessel for sea transport to the gross tonnage of the vessel (GT). It also relates GT to the power, speed and container cargo capacity: varying the capacity of the ship for a given route may give an idea of the function of unit costs per platform or trailer, which would allow us to know the optimum capacity (lowest cost) for that route. We can also know the speed of the ship as it is related to its cargo capacity. Figure 2 shows that the new price offered by the shipping company to the trailer owners for use of this system would be: 1,135 €/trailer (0.057 €/kg). In order to determine the final Ro-Ro and Ro-Pax costs to the horticultural operator, we must add the fixed costs of the truck on board, the port-to-port road transport, the toll costs and a profit margin for the logistics firm (all of which appear in Appendix A).

The resulting market share of each of the above scenarios is reflected in Table 7. The results are seen to be quite realistic in comparison with the current situation: the model predicts that, with the real value of the variables, transport by sea is only chosen in 1.12% of cases, land transport being preferred in the remaining 98.88%. In the most optimistic of the predicted scenarios (Year 2020), market share could increase to 61% given assumption a) or 78% taking assumption b). It should be noted that the use of the optimum vessel would bring about a considerable decrease in the cost of the maritime service, and, therefore, greater usage.

(22) This is a realistic assumption given the stagnation of prices in recent horticultural campaigns [Pérez-Mesa (2009)].

Figure 2: Relationship between cost per trailer and capacity of vessel[a]



[a] This model is based on a sample of 31 vessels.

Source: Own elaboration.

Table 6: Cost summary (€). Sea transport and Road transport (Almeria-Port Vendres-Perpignan-Almeria)

Cost Per Trailer (Almería-Port Vendrès)	Ro-Pax	Ro-Ro	Optim. Ro-Pax	Optim. Ro-Ro	Road
Oil Consumption (sea+road)	325	325	218	218	739
Ship freight / Road Costs per time (drivers)	1,141	900	1,080	705	1,121
Upload and Download/Road Cost per kilometer (*)	620	485	475	475	321
Others	207	207	170	170	148
Total (sea+road)	2,293	1,917	1,943	1,568	2,329
10% Profit	229	192	194	157	233
Total (€/Trailer)	2,524	2,109	2,137	1,725	2,562
€/kg (Trailer=20,000 kg)	0.1262	0.1055	0.1069	0.0862	0.1280

(*) Without Oil.

Source: Own elaboration.

Table 7: MARKET SHARE OF THE MARITIME TRANSPORT OPTION. (OPTIMAL VESSEL VERSUS REAL VESSEL)

Year	2008	2014	2020
Assumption a. % Optimum Ro-Pax	7.8%	62.1%	94.3%
Assumption a. Ro-Pax	1.1%	12.2%	61.7%
Assumption a. % Optimum Ro-Ro	18.7%	82.8%	98.1%
Assumption a. Ro-Ro	3.0%	30.6%	85.5%
Assumption b. % Optimum Ro-Pax	7.8%	70.4%	97.7%
Assumption b. Ro-Pax	1.1%	19.6%	78.3%
Assumption b. % Optimum Ro-Ro	18.7%	87.5%	99.2%
Assumption b. Ro-Ro	3.0%	43.7%	93.0%

Source: Own elaboration.

4. CONCLUSIONS AND RECOMMENDATIONS

With the aim of studying the potential demand for alternatives to road transport, this paper presents an application of the theory of random utility and of discrete choice models, considering the possibilities of short-distance sea transport. This mode of transport is one of the alternatives which has been promoted by recent European policy. Despite the disadvantages of sea transport in comparison to transport by road (e.g. greater transit time and risk), it does have its positive aspects, mainly associated with energy and environmental advantages. However, in the Spanish case, its potential as an alternative means of transport is influenced positively by factors such as the outlying location compared to the European markets, the availability of port infrastructure and the falling costs, as opposed to the rising costs of transport by road.

The empirical analysis carried out takes the case of agrifood exporters from Southeast Spain as its reference, using technical data for the sea route between the Port of Almería and that of Port Vendres-Perpignan (Southeast France). This route is of interest not only due to the above-mentioned positive factors, but also because of the need to reduce congestion over the Pyrenees, the strategic nature of exports to Central European countries and the possibility of creating a logistics centre for the forwarding of produce from the north of Africa.

Following the recommendations of Baird (2007), several attributes have been considered. These take into account technical and economic aspects for the establishment of motorways of the sea on the above-mentioned route, which has served as the basis for a survey on preferences regarding modes of transport on the part of exporters from Southeast Spain.

The estimation of discrete choice models has allowed us to characterize the systematic and unobserved heterogeneity in preferences for the use of land and sea transport. The results of the Binomial Logit show that the cost, time and aggregated value are attributes which determine the choice of transport mode. In particular, an increase in these variables could lead to a reduction in the choice of sea transport. Furthermore, an increase in preference for a multimodal system may arise as a result of an increase in the frequency of transport services. The results of the Mixed Logit show a similar influence of these variables on preferences for means of transport. Nevertheless, this model has been able to detect unobserved heterogeneity in the preferences in relation to the variables of transit cost and time, which suggests the need to consider future works analyzing the individual characteristics of the exporting firms.

By elaborating several scenarios, based on the estimated parameters, we can predict the tendencies for market share over the next few years (reference framework 2014 and 2020), showing that an adequate reduction in transit cost and time for the maritime service could make it a complementary means of transport to road transport. It is seen that this reduction and adaptation of this variables could be brought about by using vessels of greater capacity and speed than those currently on offer on this route. Such vessels would cause a change in transport choices. From a technical point of view, this study also shows that Ro-Ro transport (load unaccompanied by the truck driver, only the container is transported) is preferable to Ro-Pax (load accompanied by the truck driver, all the vehicle is transported)[23].

We consider that certain recommendations can be derived from the present analysis. In the current market situation, land transport will not undergo any great change in the medium term (the estimation shows a mere 7% market share for maritime transport). Policies to foment sea transport, along with measures from port authorities, could be directed at cost reductions, such as improving handling in the ports of departure and destination, as this item accounts for 12.6% and 32% of the fixed costs of shipping.

The main limitation of the present work may well be that it has analyzed a single transit route. In addition, this route is characterized by the export of horticultural produce (both processed and perishable produce, with the latter representing the bulk of current transport), and these goods imply special needs for long-distance transport. Nevertheless, the analysis system developed and the methodology followed may serve as a reference for other studies and projects related with alternative means of transport in the framework of policies promoting alternatives to transport by road. In particular, some technical specifications for sea transit are of interest in the case of Spain, which has a well developed port infrastructure and sectors dedicated to agrifood exports to the European market.

Likewise, this study points the way for future works aimed at a more specific analysis of the political implications of developing sea transport. Moreover, the empirical evidence provided suggests that the heterogeneity of preferences regarding alternative means of transport may be linked to certain socioeconomic factors of the potential users. It would, therefore, be of interest to study this issue in greater detail.

(23) However, the latter implies less logistic coordination than the former since neither truck drivers nor cabs need to be contracted at destination and because less port infrastructure is required.

Appendix A

Cost of sea and land transport

The most suitable form of maritime transport is considered to be Ro-Pax, i.e. “accompanied” transit. This is preferred to “unaccompanied” transit since we are dealing with perishable produce requiring constant care in all phases of transit. The Ro-Pax system also minimizes the need for port infrastructure. Nevertheless, this study also analyses the cost of the “unaccompanied” Ro-Ro alternative. The current exploitation regime requires the use of existing vessels in a time-charter regime as there is, as yet, no regular line available. Cost and timetables (Almería-Port Vendres) of the system described above are shown in Table A.1. Details about the journey Almería-Port Vendres can be summarized as follows:

– Crossing from Almería to Port Vendres at 18 knots: approx. 30 h.
– Departures from Almería: Saturday at 18 h. and Tuesday at 22 h.
– Arrivals in Port Vendres: Monday at 2 h. and Thursday at 6 h.
– Departures from Port Vendres: Monday at 8 h. and Thursday at 12 h.
– Arrivals in Almería: Tuesday at 16 h. and Saturday at 00 h.

The cost of the return journey according to Table A.1 would be 1,351 euros per trailer [194,585 euros / (72 trailers x 2 weekly trips)]. To this, we must add 10% profit, so the total price for the service comes to 1,486 euros per trailer (return).

It is assumed that trucks are only full on the outward journey (with a load of 20,000 kg per trailer). The cost per kilo which the transport owner offers the horticultural operator (assuming that the truck embarks) is at least 0.074 euros (to cover sea transit). To this amount, we must add the cost of transport to the port of departure and from the port of arrival to the final destination (total 150 kilometres = 171 €; 0.0086 €/kg), the fixed costs (by time) of the truck (insurance + tax costs + driver’s expenses + driver 3.5 days = 626 €; 0.0313 €/kg), the toll cost (0.0005 €/kg) and a profit margin (10% over cost). Therefore, the total Ro-Pax cost is 0.1262 €/kg. To calculate the Ro-Ro cost, the “time costs” corresponding to the truck will be reduced while it is on board, namely, driving staff. The new fixed costs of the truck on board are 0.0125 €/kg. According to the calculation made, the price of Ro-Ro transport is now 0.1055 €/kg, i.e. 17% less than Ro-Pax. We should bear in mind that the cost could be halved if the trucks were loaded on the return journey.

The journey to the wholesale market in Perpignan is 1,032 kilometres. The direct cost of a loaded truck is 1,142 €/km; while, unloaded, it is 0.971 euros/km (Table A.2). Total cost of a loaded truck outward bound only would be 2,181 euros. Assuming a load of 20,000 kg, the cost per kilo would be 0.109 euros and other expenses (tolls + tariffs) = 0.0074 euros/kg. A margin of 10% must be applied to this cost. The total cost of road transport is 0.1281 €/kg. As above, the cost could be halved if the trucks were to return loaded.

A sensitivity analysis for the price of each system with respect to variations in fuel prices shows that, for example, a 30% increase would result in a price of 0.1404 €/kg for land transport (an increase of 9.51%). The price offered for the intermodal service to the horticultural operator would be 0.1320 €/kg, i.e. an increase of only 4.61%. In other words, land transport is twice as sensitive to an increase in fuel prices as sea transport.

In addition we have studied the necessary characteristics for a ship to minimize the cost of the route under analysis (Almería-Port Vendres). As Baird (2004) states, when analyzing the feasibility of fast sea transport services, both technical conditions (types of ships) and economic ones should be taken into account. We have, therefore, applied the optimization model developed by Ametller (2007). This model relates the cost of a Ro-Ro ship with its gross tonnage (GT). It also relates GT with the power, speed and optimum load of containers. This model is based on a sample of 31 Ro-Ro ships. Although the results (see Figure 2) are approximate, they provide valuable information as they show that the transport capacity of the optimum ship to minimize the cost per platform would transport 250 containers at a speed of 24 knots. Given these data, the new price offered by the shipping company to the trailer owners for use of this system would be 1,135 €/trailer (0.057 €/kg). Totalling the fixed costs (by time) of the truck on board (0.0313 €/kg), the road transport port-to-port (0.0086 euros/kg), the toll costs (0.0005 euros/kg) and a profit margin (10% over cost), the new price offered for the intermodal Ro-Pax service to the horticultural operator is 0.1069 €/kg. To convert this to Ro-Ro costs, we only have to reduce the time costs corresponding to the truck on board (i.e. change 0.0313 €/kg to 0.0125 €/kg, as was done previously) and to apply the profit margin: the new final cost is 0.0862 €/kg.

Table A.1: Cost of a vessel for 7 days with destination in Port Vendres

Fixed costs	Total, €	% cost
Consumption (16 €/Mile)	38,450	19.8%
Ship freight	58,870	30.2%
Upload and Download		
Almería + handling	24,560	12.6%
Upload and Download		
Port Vendres + handling	62,315	32.0%
Administration staff	440	0.2%
Total fixed cost per cycle and vessel	184,635	94.9%
Variable costs	total, €	
Insurance of goods	8,500	4.4%
Total variable cost per cycle and vessel	8,500	4.4%
Commercial discount: 60 days	1,450	0.7%
Total financial cost per cycle and vessel	1,450	0.7%
Total costs in 7 Days	194,585	100%
Estimated Occupation	No. trailers per vessel	% occupation
% Occupation outward bound	72	(*) 90%

(*) 72 vessels out of 80 possible.

Source: Own elaboration based on Almerian Port Authority data.

Table A.2: Direct annual cost of an articulated refrigerated vehicle

	Euros	%
Costs per time	65,179.27	55.94
Payment of vehicle	15,296.59	13.13
Financing vehicle	2,573.44	2.21
Drivers	26,322.25	22.59
Insurance	7,145.68	6.13
Tax costs	893.31	0.77
Expenses	12,948.00	11.11
Costs per kilometre	51,337.93	44.06
Fuel	39,462.93	33.87
Tyres	5,851.00	5.02
Maintenance	2,064.00	1.77
Repairs	3,960.00	3.40
Total Direct Costs	116,517.20	100
Annual km	120,000	
Annual km loaded	102,000	
Costs (€/km no load)	0.971	
Costs (€/km loaded)	1.142	

Power 420 CV; Maximum authorised mass = 40,000 kg; useful load = 24,000 kg; 5 axles, 12 tyres.
Source: Market observatory for road transport of merchandise (31 October, 2006).

Appendix B

Table B.1: Summary of the calculation of scenarios

Summary of the actual value of variables (and future scenarios) used to sea transport and to calculate market share estimated to top:	2008	2014	2020
Assumptions a and b. Cost by sea. Current supply for Ro-Pax.	0.1262 €/kg	0.1366 €/kg	0.1460 €/kg
Assumptions a and b. Cost by sea. Current supply for Ro-Ro.	0.1055 €/kg	0.1127 €/kg	0.1192 €/kg
Assumption a. % complaints by sea	18%	15%	13%
Assumption a. transit time by sea (hours)	30 h	28 h	26 h
Assumption a. journeys sea /week	3 jour/w	5 jour/w	6 jour/w
Assumption b. % complaints by sea	18%	14%	10%
Assumption b. transit time by sea (hours	30 h	27 h	25 h
Assumption b. journeys sea/week	3 jour/w	5 jour/w	7 jour/w
Assumptions a and b. Unit value by sea	0.5 €/unit	0.5 €/unit	0.5 €/unit
Summary of changes resulting from the use of an Optimal vessel at 24 knots (250 containers) used to calculate market share estimated to top:	**2008**	**2014**	**2020**
Assumptions a and b. Cost by sea Optimum Ro-Pax	0.1069 €/kg	0.1146 €/kg	0.1217 €/kg
Assumptions a and b. Cost by sea Optimum Ro-Ro	0.0862 €/kg	0.0924 €/kg	0.0981 €/kg
Assumption a. % complaints by sea	18%	15%	13%
Assumption a. transit time by sea (hours)	30 h	28 h	26 h
Assumption a. journeys sea /week	3 jour/w	5 jour/w	6 jour/w
Assumption b. % complaints by sea	18%	14%	10%
Assumption b. transit time by sea (hours	30 h	27 h	25 h
Assumption b. journeys sea / week	3 jour/w	5 jour/w	7 jour/w
Assumptions a and b. Unit value by sea	0.5 €/unit	0.5 €/unit	0.5 €/unit

Table B.1: SUMMARY OF THE CALCULATION OF SCENARIOS (continuation)

Summary of the actual value of variables (and future scenarios) to land transport and used to calculate market share estimated to top:	2008	2014	2020
Assumptions a and b. Cost by road	0.1281 €/kg	0.1709 €/kg	0.2088 €/kg
Assumption a. % complaints by road	10%	10%	10%
Assumption a. transit time by road (hours)	14 h	16 h	17 h
Assumption a. journeys sea /week	6 jour/w	6 jour/w	6 jour/w
Assumption b. % complaints by road	10%	10%	10%
Assumption b. transit time by road (hours	14 h	17 h	19 h
Assumption b. journeys sea / week	6 jour/w	6 jour/w	6 jour/w
Assumptions a and b. Unit value by road	0.9 €/unit	0.9 €/unit	0.9 €/unit

Source: Own elaboration based on Almerian Port Authority data.

Appendix C

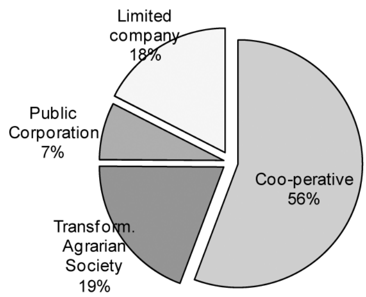
The sample set includes 39 companies which answered our questionnaires. This sample represents 16% of total exports from the region (Almería+Granada+Murcia) under study (FEPEX, 2008). Taking only Almería into consideration, the sample represents 35% of exports.

Table C.1: Summary of general data of the sample (39 companies)

Variable	Mean value	Standard deviation	Minimum	Maximum	Median	Fisher Kurtosis index
Marketed volume (t)	34,555	11,101	28,861	61,043	31.112	2.282
Exports volume (t)	19,085	4,685	17,839	27,469	17.743	1.823
Employees	155	39	92	215	162	-1.643

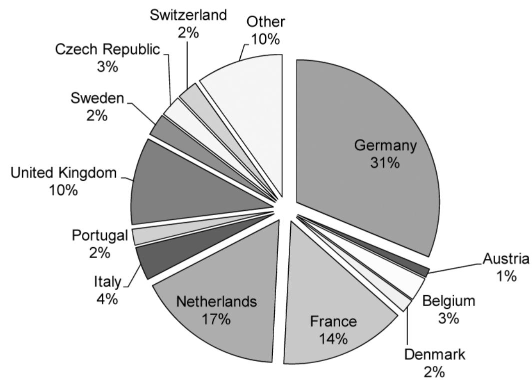
Source: Own elaboration.

Figure C.1: Percentage of marketed volume according to the type of firm in the sample



Source: Own elaboration.

Figure C.2: EXPORTS DESTINATION IN THE SAMPLE



Source: Own elaboration.

REFERENCES

Amador, F.J. and González, R.M. (2005): "El valor subjetivo del tiempo de viaje de los estudiantes universitarios cuando las preferencias son heterogéneas", *Hacienda Pública Española*, nº. 174, pp. 25-41.

Ametller, X. (2007): "Optimización del transporte de mercancías mediante el transporte marítimo de corta distancia". Universidad Politécnica of Cataluña. Minor thesis. Online: *https://upcommons.upc.edu/pfc/handle/2099.1/4942*

Barnard, B. (2004): "Breaking the trucking habit", *Journal of Commerce*, 15 (March).

Baird, A. (2004): "Investigating the Feasibility of Fast Sea Transport Services". *Maritime Economics & Logistics*, vol. 6, nº. 3, pp. 252-269.

Baird, A. (2007): "The economics of Motorways of the Sea", *Maritime Policy & Management*, vol. 34, nº. 4, pp. 287-310.

Ben-Akiva, M.E., Lerman, S. (1985): *Discrete Choice Analysis*. MIT Press, Cambridge.

Ben-Akiva, M.E. and Bolduc, D. (1996): "Multinomial probit with a logit kernel and a general parametric specification of the covariance structure". Working Paper, Department d'Economique, Université Laval.

Bhat, C.R. (2000): "Quasi-random maximum simulated likelihood estimation of the mixed multinomial logit model", *Transportation Research*, nº. 35B, pp. 677-693.

Brownstone, D. and Train, K. (1999): "Forescating new product penetration wit flexible substitution patterns", *Journal of Econometrics*, vol. 89, pp. 109-129.

Brownstone, D. (2001): "Discrete choice modelling for transportation", in Hensher D. *Travel Behaviour Research: The Leading Edge*, Pergamon Press, Oxford, pp. 97-124.

De Pablo, J., Pérez-Mesa, J.C. and Lévy, J.P. (2006): "Notes About the Production and Supply-Demand of Fruit and Vegetables in the Countries of the European Union", *Journal of Food Products Marketing*, vol.13, nº. 3, pp. 95-111.

De Pablo, J. and Pérez-Mesa, J.C. (2004): "El entramado de empresas almerienses de economía social dedicadas a la comercialización agraria: descripción, problemas generales y perspectivas de competitividad". *Revista Española de Estudios Agrosociales y Pesqueros*, nº. 202, pp. 71-100.

De Pablo, J. and Pérez-Mesa, J.C. (2005): "Factibilidad del aumento de la exportación europea de tomate a EE.UU: el caso español", *Información Comercial Española, ICE: Revista de Economía*, nº. 820, pp. 235-248.

Domencich, T. and McFadden, D. (1975): *Urban Travel Demand: A Behavioural Analysis*. North-Holland, Amsterdam.

European Commission (2008): "Las autopistas del mar y su integración en la cadena logística". TEN/305, Brussels.

FEPEX, Federación Española de Asociaciones de Productores y Exportadores de Frutas, Hortalizas, Flores y Plantas Vivas (2008). *Estadísticas de exportación*. http://www.fepex.es

Galdeano, E. (2003): "The Role of Co-operatives in the Competitiveness of the Horticultural Sector", *Journal of Co-operative Studies*, vol. 36, nº. 3, pp. 190-213.

Galdeano-Gómez, E. (2010): "Exporting and environmental performance: a firm-level productivity analysis", *The World Economy*, vol. 33, nº. 1, pp. 60-88.

García, L. and Vallejo, J.A. (2003): "Determinación del área de influencia de las instalaciones portuarias: ejemplo de los puertos de Almería-Motril", XVII Reunión anual Asepelt, Almería, 19-20 junio.

González, F. and Novo, I. (2007): "Las autopistas del mar en el contexto europeo", *Boletín ICE*, nº. 2902, pp. 33-47.

Guirao, G., González, R. and Pérez, N. (1995): "Una aplicación de los modelos de elección discreta al transporte interinsular de pasajeros", *Estudios de Economía Aplicada*, nº. 4, pp. 71-86.

Hess, S., Bierlaire, M. and Polak, J.W. (2005): "Estimation of value of travel-time savings using mixed logit models", *Transportation Research*., vol.39, pp. 221-236.

Kapros, S. and Panou, C. (2007): "Coastal shipping and intermodality in Greece: the weak link", *Research in Transportation Economics*, vol. 21, pp. 323-342.

Liem, T. and Gaudry, M. (1997): "PROBABILITY: The P-2 to P-6 programs for the Standard and Generalized BOX-COX LOGIT and DOGIT and for the Linear and Box-Turkey INVERSE POWER TRANSFORMATION-LOGIT models with disaggregate data". Working Paper BETA nº. 9802, December.

Marchese, U. and Musso, E. (2002): "Economics of Shortsea Shipping", in Grammenos C. Th. (ed) «*The Handbook of Maritime Economics and Business*», Lloyds of London Press, London, pp. 280-304.

Márquez, L., Martínez, I., Pérez, E. and Wilmsmeier, G. (2007): "Determinantes de los costes de transporte marítimos. El caso de las exportaciones españolas", *Información Comercial Española, ICE: Revista de economía*, nº. 834, pp. 79-93.

McFadden, D. (1974): "The measurement of urban travel demand", *Journal of Public Economics*, vol. 3, pp. 303-328.

McFadden, D. (1978): "Modelling the choice of residential location". In: A. Karquist *et al.* (eds.), *Spatial Interaction Theory and Planning Models*. North-Holland Press, Amsterdam.

McFadden, D. (1981): "Econometric models of probabilistic choice". In: Manski, C.F. and McFadden, D. (eds.), *Structural Analysis of Discrete Data with Econometrics Applications*, pp. 198-272.

McFadden, D. and Train, K. (2000): "Mixed MNL models for discrete response", *Journal of Applied Econometrics*, vol. 15, nº. 5, pp. 447-470.

Ministerio de Fomento (2007): *Observatorio hispano-francés de Tráfico en los Pirineos*. Secretaría de Estado de Transportes, Madrid.

Morera, F. J. and González, R. M. (2005): " El valor subjetivo del tiempo de viaje de los estudiantes universitarios cuando las preferencias son heterogéneas", *Hacienda Pública Española*, nº. 174, pp. 25-42.

Morey, E. and Rossman, K. (2002): "Using stated-preference questions to investigate variation in willingness to pay for preserving marble monuments: classic heterogeneity and random parameters", Working Paper, Economics Department, Unversity of Colorado at Boulder.

Napier University (2002): "UKMM - United Kingdom Marine Motorways Study, Future Integrated transport (FIT) Link Programme", Department for Transport and Engineering & Physical Science Research Council (EPSRC), Edinburgh.

Ortúzar, J. D. and Willumsem, L.(2001): *Modelling Transport* (3ªed), Wiley, Chichester.

Paixao, A. and Marlow, P.B. (2001a): "A review of the European Union Shipping Policy", *Maritime Policy & Management*, vol. 28, nº. 2, pp. 187-198.

Paixao, A and Marlow, P.B (2001b): "Strengths and weaknesses of short sea shipping", *Marine Policy*, vol. 26, nº. 3, pp. 167-178

Pérez-Mesa, J.C. and De Pablo, J. (2007): "Caracterización del comercio internacional de frutas y hortalizas en la UE", *Estudios de Economía Aplicada*, vol. 25, nº. 3, pp. 619-642.

Pérez-Mesa, J.C., Salinas, J., Céspedes, J., Galdeano, E. and Plaza, J. (2009): "Distribución óptima del transporte intermodal: aplicación a la exportación de perecederos". VII Congreso de Economía Agraria. 16-18 Septiembre. Almería (España).

Pérez-Mesa, J.C. (2009): "El sector hortofrutícola almeriense frente a los cambios en la oferta y demanda internacional". *Informe Anual del sector Agrario en Andalucía* 2008, pp. 364-376.

Salinas, J.A. and Bayo, A. (2008): "Almería practical study. Market study and cost benefit analysis at micro level", Project D 7.12, European Commission and the trans-Eurpean networks budget (TEN-T), Ministerio de Fomento.

Salinas, J.A. and Palao, F. (2006): *Posibilidades de Desarrollo del Tráfico Hortofrutícola por los Puertos de Almería y Motril*, Universidad de Almería.

Sakalys, A. and Palsaitis, R. (2006): "Development of intermodal transport in new European Union States", *Transport*, vol. 21, nº. 2, pp. 148-153.

Schreyer, C., Maibach, M., Rothengatter W., Doll, C. and Schmedding, D. (2004): *Costes externos del transporte: estudio de actualización*. Universidad de Karlsruhe.

Tongzon, J. and Sawant, L. (2007): "Port choice in a competitive environment: from the shipping lines' perspective", *Applied Economics*, vol. 39, nº. 4, pp. 477-492.

Train, K. (1998): "Recreation demanda models with taste differences over people", *Land Economics*, vol. 74, nº. 2, pp. 230-239.

Train, K. (1999): "Halton sequences for mixed logit", Working Paper, Department of Economics, University of California, Berkeley.

Train, K. (2003): *Discrete Choice Methods with Simulation*, Cambridge University Press, Cambridge.

Train, K. and MacFadden, D. (1978): "The goods/leisure trade-off and disaggregate work trip mode choice models", *Transportation Research*, vol. 12, pp. 349-353.

Vidal, J.F. (2007): "Autopistas del mar y desarrollo portuario: desde la visión europea al enfoque de la comunidad portuaria". Working Paper, Shortsea Promotion Center.

Fecha de recepción del original: marzo, 2009
Versión final: marzo, 2010

RESUMEN

Este trabajo analiza la demanda potencial del transporte marítimo para exportaciones agroalimentarias. La metodología de estudio se basa en la teoría de la utilidad aleatoria y la aplicación de los modelos de elección discreta para dos medios de transporte alternativos: terrestre y marítimo. El análisis empírico toma como referencia la posibilidad de aumento del transporte marítimo entre el sureste de España y el sureste de Francia. Con la estimación de un Logit binomial y un Logit mixto se muestra que la elección del exportador depende, principalmente, del coste y el tiempo de tránsito. Con dichas estimaciones se aborda un análisis de diferentes escenarios considerando cambios en los atributos del modelo. Como resultado, se predicen las cuotas de mercado de cada sistema de transporte.

Palabras clave: transporte marítimo y terrestre, logística.

Clasificación JEL: F14, L91, R42.