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A FREIGHT TRANSPORT DEMAND MODEL TO EVALUATE POLICY ACTIONS FOR SHORT SEA SHIPPING IN SICILY

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ABSTRACT

This research aims at developing a modelling tool to predict the impact of different policies on the modal split of the freight transport demand in Sicily (in particular, road versus short sea shipping). To gain this objective, a random utility model, precisely a *nested logit* one, has been formulated and estimated trough a *stated preference* (*SP*) survey which has involved about 40 road-based freight transport Sicilian firms. The resulting demand model has been applied to forecast the modal split scenarios deriving from several projects regarding the Sicilian freight mobility system (some projects are public plans and other ones are proposed by the authors).

Keywords: freight transport demand in Sicily, short sea shipping, logistic terminals, random utility models, *stated preference* surveys.

INTRODUCTION

The sea-road intermodality development in Sicily is hindered by the critical condition of the regional port system, that can be ascribed to the following weak points:

— The most important ports are placed in congested urban areas, thus suffering from limitations on their development;

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— The most important port nodes show low degrees of accessibility (conflict between the truck traffic and the private car one);
— Low levels of automation for port functions.

Furthermore, statistical data from the port authority of Palermo, which has a leading role in the sea-road intermodality market, highlight that, in the last years, the use of semi trailers in Ro-Ro freight transport has shown a 30% incidence, which implies a wide range of potential improvement in terms of efficiency. This critical aspect can be related to the following findings of a survey on the Italian road freight transport sector, conducted by a division of the Trucker National Register, in 2000 and 2004: the Sicilian road transport market is characterized by a great presence of small-sized enterprises (≤ three vehicles), which represent about the 68% of the whole sector; moreover, in about the 86% of the cases, the operators aren't included in unions; it follows that their propensity to technological innovations is very low.

The above-explained considerations have induced the authors to build a modelling tool for supporting the Sicilian policy of short sea shipping by simulating the Ro-Ro market shares stemming from several projects, some of which are public plans, while other ones are proposed by the authors.

SURVEY OF LITERATURE

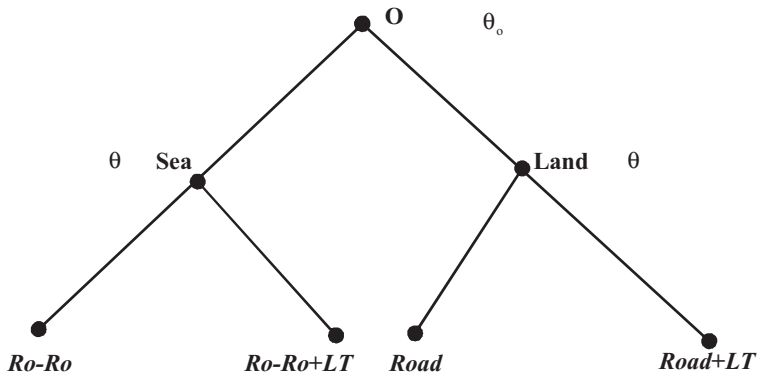
The study under consideration rests on the literature about freight transport demand modelling, with respect to the mode choice simulation. In particular, the aforesaid research focuses on *consignments models*, which can reproduce the transport mode choice process, carried out by a producer or a shipper for a single consignment, by applying the *random utility theory* (Ben Akiva and Lerman, 1985; Ortùzar and Willumsen, 1994). Furthermore, a contribution has derived from the current of research on the estimation of the above-mentioned demand models trough *stated preference* data (Bolis and Maggi, 1999; Bolis and Maggi, 2002; Cascetta et al., 1996; Danielis and Rotaris 1999; Danielis and Rotaris 2002; Fowkes and Shinghal; Fridstrom and Madslien, 2002; Maier and Bergman, 2001; Mangan et al., 2002).

MODEL FRAMEWORK

As stated before, the authors' aim consists in developing and calibrating a *nested logit* model, through a *stated preference* survey, to simulate the mode choice of sicilian freight transport operators (in particular, road versus short sea shipping), allowing for the possibility of demanding the utilities supplied by logistic terminals, that are on the agenda of regional policy makers (Dipartimento Trasporti e Comunicazioni della Regione Sicilia, 2003)[1]. In detail, the resulting decision-making process has been represented according to a sequential approach: there is a first stage of choice

between the "Sea" option and the "Land" one; at the second step, under the two above-mentioned cases, the decision maker consider the possibility of using a logistic terminal (see Fig. 1).

Fig. 1: Modal split model structure



θ_o: parameter determining the variance of the first decision-making step error term ("Sea" versus "Land");
θ: parameter determining the variance of the second choice level error term.

To model Sicilian truckers' choice behaviours, the following explanatory variables have been introduced: door to door transport service price (Cost); travel time (Time); service frequency (Freq); risk of delay (Delay); risk of damage for goods (Damage) and a dummy variable for the logistic terminal case (LT). So, the perceived utility functions associated with the four alternative modes of transport can be expressed as follows:

$$U_{Ro-Ro} = V_{Ro-Ro} + \varepsilon_{Ro-Ro} = V_{Ro-Ro} + \eta_{Sea} + \tau_{Ro-Ro/Sea} \quad (1)$$

$$U_{Ro-Ro+LT} = V_{Ro-Ro+LT} + \varepsilon_{Ro-Ro+LT} = V_{Ro-Ro+LT} + \eta_{Sea} + \tau_{Ro-Ro+LT/Sea} \quad (2)$$

$$U_{Road} = V_{Road} + \varepsilon_{Road} = V_{Road} + \eta_{Land} + \tau_{Road/Land} \quad (3)$$

$$U_{Road+LT} = V_{Road+LT} + \varepsilon_{Road+LT} = V_{Road+LT} + \eta_{Land} + \tau_{Road+LT/Land} \quad (4)$$

$$V_{Ro-Ro} = \beta_T \cdot Time + \beta_C \cdot Cost + \beta_F \cdot Freq + \beta_D \cdot Delay + \beta_{DA} \cdot Damage \quad (5)$$

$$V_{Ro-Ro+LT} = \beta_{LT} \cdot LT + \beta_T \cdot Time + \beta_C \cdot Cost + \beta_F \cdot Freq + \beta_D \cdot Delay + \beta_{DA} \cdot Damage \quad (6)$$

$$V_{Road} = \beta_T \cdot Time + \beta_C \cdot Cost + \beta_F \cdot Freq + \beta_D \cdot Delay + \beta_{DA} \cdot Damage \quad (7)$$

$$V_{Road+LT} = \beta_{LT} \cdot LT + \beta_T \cdot Time + \beta_C \cdot Cost + \beta_F \cdot Freq + \beta_D \cdot Delay + \beta_{DA} \cdot Damage \quad (8)$$

Where, considering j = "Ro-Ro", "Ro-Ro+LT", "Road", "Road+LT" and K = "Sea", "Land":

— U_j: perceived utility if a shipment is carried out by mode j.
— V_j: systematic part of .
— ε_j: random part.
— η_K: random error associated with composite alternative K.
— $\tau_{j/K}$: random error associated with alternative j.
— $\beta_T, \beta_C, \beta_F, \beta_D, \beta_{DA}, \beta_{LT}$: coefficients.
— Cost: transport service price (10^3 euros).
— Time: travel time (hours).
— Freq: service frequency binary variable (1: high; 0:low).
— Delay: risk of delay binary variable (1: high; 0:low).
— Damage: risk of damage for goods binary variable (1: high; 0:low).
— LT: dummy variable for the logistic terminal case (1 if a logistic terminal is used; 0 otherwise).

Under the *nested logit* framework, in the different cases, the probability of choosing a mode of transport can be written as follows:

$$p\left[Ro-Ro\right] = p\left[Ro-Ro/Sea\right] \cdot p\left[Sea\right] \quad (9)$$

$$p\left[Ro-Ro+LT\right] = p\left[Ro-Ro+LT/Sea\right] \cdot p\left[Sea\right] \quad (10)$$

$$p\left[Road\right] = p\left[Road/Land\right] \cdot p\left[Land\right] \quad (11)$$

$$p\left[Road+LT\right] = p\left[Road+LT/Land\right] \cdot p\left[Land\right] \quad (12)$$

The complete formulation of the mode choice probability is showed below only in relation to the Ro-Ro alternative, since it presents the same structure for the various options:

$$P_{Ro-Ro} = \frac{\exp(V_{Ro-Ro}/\theta)}{\exp(V_{Ro-Ro}/\theta)+\exp(V_{Ro-Ro+LT}/\theta)} \cdot \frac{\exp\left\{\delta \ln\left[\exp(V_{Ro-Ro}/\theta)+\exp(V_{Ro-Ro+LT}/\theta)\right]\right\}}{\exp\left\{\delta \ln\left[\exp(V_{Ro-Ro}/\theta)+\exp(V_{Ro-Ro+LT}/\theta)\right]\right\}+\exp\left\{\delta \ln\left[\exp(V_{Road}/\theta)+\exp(V_{Road\ LT}/\theta)\right]\right\}}$$

$$\delta = \theta/\theta_o \tag{13}$$

In order to calibrate the above-explained demand model, an *SP* survey has been carried out. The *SP* technique is a market research survey tool to analyse individual preferences towards completely new products or services and those factors affecting the demand of existing goods, in relation to which no set of *revealed preference data* (*RP*) is available. In more detail, such a method consists in the presentation to individuals of imaginary situations (although realistic) characterized by the availability of several choice options (described by quantitative and qualitative attributes), among which respondents can be asked to choose the most preferred alternative. So, an *SP* experiment permits the researcher to quantify the impact on preferences of each attribute (*main effects*) and of the most significant interactions between attributes, that can be defined as the effects of two or more factors which, when acting together, produce an influence different from the sum of the their individual effects.

The attributes selected for an *SP* survey vary according to a pre-specified set of levels (e.g. different values of a price). The set of choice scenarios deriving from all the possible combinations of the attribute levels is named *full factorial design*; when its size becomes high, respondents will experience fatigue in doing the choice exercises. The scientific literature (Cascetta, 2001; Ortùzar and Willumsen, 1994; Louviere et al., 2000; Permain and Swanson, 1991) suggests several approaches (*experimental design* techniques), to reduce the number of scenarios to be presented to the decision makers, that can be employed in conjunction with each other.

One of the most used methods is the *block design* one requiring the division of the choice set (*full factorial design*) into sub-sets (blocks) that are submitted to different groups of respondents drawn from the sample. The technique under consideration is to be performed in the following way: a *block variable* (corresponding to an interaction between two or more attributes) is selected and the scenarios are divided into as many clusters as the levels of the *block variable* (low/high). The researcher can also use different *block variables*; in this case, the blocks are formed according to the interaction of the *block variables*[2]. Such a procedure leads to blocks with choice scenarios showing, for each attribute, the low level as many times as the high one and, for every interaction between any two attributes, the concordance case (low/high level for both items) as many times as the discordance one (low level for an attribute and high level for the other one).

To achieve the same outcome, one could apply another widely adopted approach, that is the *fractional factorial design* one. It rests on the assumption that some or all interactions between attributes are negligible, since the scientific literature (Cascetta, 2001; Ortùzar and Willumsen, 1994; Louviere et al., 2000; Permain

and Swanson, 1991) states that, in practise, *main effects* explain the largest amount of variance in response data, 80% or more. Under this method, the number of choice exercises can be reduced by making the levels of some attributes correspond to the ones of interactions between the remaining factors (the most important ones), whose levels are drawn from a *full factorial design* built by excluding the attributes to be confounded with interaction terms[3].

APPLICATION

The levels of the mode choice attributes

The levels of the explanatory variables, selected to investigate the choice behaviour of road-based carriers, have been determined by a data set concerning a sample of origin-destination links involving Sicily. In particular, a comparison between the road mode and the Ro-Ro one has been effected in terms of travel time and transport monetary cost, with respect to freight traffic from/towards Sicily (generators/attractors: Trapani, Caltanissetta, Ragusa) towards/from Northern Italy (attractor/generator: Milano), Central Italy (attractor/generator: Perugia), Southern Italy (attractor/generator: Potenza).

Such an approach has implied a high degree of realism for the choice scenarios submitted to the sample of Sicilian truckers. In more detail, the estimations executed to construct the afore-said data set are based on the following assumptions and information:

- the average transport monetary cost, in the case of the road mode, is 1.354 euros per truck-km (source: Trucker National Register, 2005); it has been turned into euros per ton by a load factor of 17.5 tons per vehicle.
- To calculate the travel time, in the case of the road mode, the authors have adopted mathematical formulations taking account of the national regulations on the driving time[4] (Torrieri et al., 2002).
- A nationwide survey by the authors has pointed out that a break-bulk terminal can produce a 40% rise in load factors. Furthermore, the average price for transhipment has been estimated at 2 euros per ton and the waste of time at the terminal is 4 hours under normal conditions.
- A recent study by the authors on the Sicilian ports has revealed that the average time for loading trucks is 4 hours, in the case of a cargo consisting of trucks, semitrailers and private cars.
- As for Ro-Ro routes, the main destination ports are Genova (Northern Italy), Civitavecchia (Central Italy), Napoli (Southern Italy), while the origin is the port of Palermo. In addition, data provided by shipping companies have been considered to evaluate the sea transport service cost[5] and the travel time.

— To take into account the scarce accessibility of Italian ports, the speed of trucks on the way linking the generic origin (destination) with a port has been set at 50 km/h.
— The cost of crossing the Straits of Messina (about 50 euros) is equal to the one of the berth for the driver, as a consequence, they have not been considered to compare the road mode with the Ro-Ro one.

Table 1 presents the levels of the attributes selected for the SP survey.

	ΔT * (hours)	**ΔC ** (euros)**	**Service Frequency**	**Risk of Delay**	**Risk of Damage**
Levels	5	-200	Low	Low	Low
	7	-500	High	High	High
	9	-800			
	11	-1000			

* Gap in terms of travel time between a transport mode and the "road" option.
** Gap in terms of monetary cost between a transport mode and the "road" option.

SP experiment design

To design an *SP* experiment, the scientific literature (Cascetta, 2001; Ortùzar and Willumsen, 1994; Louviere et al., 2000; Permain and Swanson, 1991) requires two levels for each attribute; therefore, both variable ΔT and variable ΔC has been broken up into two elements ($\Delta T_1, \Delta T_2, \Delta C_1, \Delta C_2$), each one of which is characterized by two levels determined so as to obtain every level of the original factors by any pair of the component variables' levels (to be summed up). The choice scenarios that can be constructed by combining the shown levels with each other are 128 (the number of levels raised to the power of the number of attributes): a choice set that can't be proposed to a decision maker; so, they have been reduced to two blocks of 8 choice exercises, to be presented to two different groups of respondents, through the joint use of the two beforedescribed *experimental design* techniques. In particular, at a first step, a *fractional factorial design* of 16 choice scenarios has been gained by making the levels of the service frequency, the risk of damage for goods and the risk of delay correspond to the ones of interactions between the other attributes[6], according to the following relations:

$$Freq = (\Delta T_1,\ \Delta T_2) \tag{14}$$

$$Delay = (\Delta T_1,\ \Delta C_1) \tag{15}$$

$$Damage = (\Delta T_2,\ \Delta C_2) \tag{16}$$

At a second stage, the *fractional factorial design* of 16 decision contexts has been subdivided into two blocks of 8 choice exercises, by using as *block variable* the interaction between ΔT_1, ΔT_2, ΔC_1, ΔC_2. The final output is reported in Tables 2, 3.

Table 2: First block of choice experiments submitted to Sicilian truckers

	ΔT (hours)	ΔC (euros)	Service Frequency*	Risk of Delay*	Risk of Damage*
Block I	11	-1000	1	1	1
	11	-200	1	0	0
	9	-400	0	1	1
	9	-800	0	0	0
	7	-400	0	0	0
	7	-800	0	1	1
	5	-1000	1	0	0
	5	-200	1	1	1

* 0: low level; 1: high level.

Table 3: Second block of choice experiments submitted to Sicilian truckers

	ΔT (hours)	ΔC (euros)	Service Frequency*	Risk of Delay*	Risk of Damage*
Block II	11	-400	1	1	0
	11	-800	1	0	1
	9	-1000	0	1	0
	9	-200	0	0	1
	7	-1000	0	0	1
	7	-200	0	1	0
	5	-400	1	0	1
	5	-800	1	1	0

* 0: low level; 1: high level.

A step further has consisted in matching each of the above-showed decision contexts with the closest one belonging to the data set employed for identifying the attribute levels, so as to present comparisons between specific modes of transport to Sicilian truckers, thus building the choice scenarios around the existing respondents' experience.

Features of the sample

The sample selected for the *SP* survey consists of 33 road-based freight transport Sicilian firms, whose representatives have been involved in face-to-face interviews. About the 51% of this group refers to small-sized firms with a number of available vehicles inferior to 10, whereas the 49% is represented by enterprises with more than 10 vehicles (only the 9% relates to operators owning at least 100 means of transport).

Model estimation

As stated before, the Sicilian haulers' preferences have been modelled by a *nested logit* formulation. In detail, the resulting decision-making process has been represented according to a sequential approach: there is a first stage of choice between the "Sea" option and the "Land" one; at the second step, under the two above-mentioned cases, the decision maker consider the possibility of using a logistic terminal. To estimate the model parameters, the authors have adopted the Alogit 4.2 software processing 264 choice observations. Table 4 shows only the coefficients of the utility

Table 4 : The nested logit model for Sicilian carriers' mode choices (Rho-Squared = 0.571).

Attributes	Coefficients	Standard Error	T Student
Time (hours)	-0.094	0.030	-3.1
Cost (10^3 euros)	-1.577	0.519	-3.0
Damage (1/0)	-0.715	0.268	-2.7
LT (1/0)	1.122	0.425	2.6
Variance, θ	0.912	0.367	2.5

function attributes that have proved statistically significant.

The resulting value of time is about 60 euros per hour; this output is validated by a recent European scale survey (CSST, 2005) on the road freight transport hourly cost (toll, fuel consumption, wear and tear on tyres, maintenance, depreciation, taxes), which for Italy reports the value of 67.8 euros per hour.

Model-based analysis of various policy action scenarios on short sea shipping

The calibrated *nested logit* model has been applied to the west side of Sicily to evaluate the effectiveness of various planning scenarios in favour of *short sea shipping*.

Tables 5a, 5b, 5c: Sicilian truckers' mode choices if Sicily were provided with logistic terminals.

O-D Link: Caltanissetta - Milano (Northern Italy)					
	Time(hours)	Cost (10^3 euros)	Damage	LT	P_{choice}^*
Ro-Ro	31.36	1.08	0	0	20.93%
Ro-Ro+LT	35.36	1.01	0	1	48.96%
Road	24.28	2.00	1	0	5.02%
Road+LT	28.28	1.46	1	1	25.09%
O-D Link: Caltanissetta - Perugia (Central Italy)					
	Time(hours)	Cost (10^3 euros)	Damage	LT	P_{choice}^*
Ro-Ro	25.96	1.09	0	0	15.88%
Ro-Ro+LT	29.96	0.97	0	1	40.38%
Road	18.91	1.45	1	0	8.76%
Road+LT	22.91	1.04	1	1	34.98%
O-D Link: Caltanissetta - Potenza (Southern Italy)					
	Time(hours)	Cost (10^3 euros)	Damage	LT	P_{choice}^*
Ro-Ro	23.96	0.87	0	0	8.60%
Ro-Ro+LT	27.96	0.79	0	1	20.50%
Road	7.94	0.87	1	0	17.59%
Road+LT	11.94	0.64	1	1	53.32%

* model-based choice probability.

In detail, with respect to different connections between Sicily and the rest of Italy, whose origin is the Sicilian province of Caltanissetta (selected owing to its barycentric position), travel times and monetary costs of the several transport modes have been estimated. Firstly, the model has been employed to predict the choice behaviour of Sicilian haulers in case Sicily were provided with logistic terminals:

As the reader can observe in Tables 5a, 5b, 5c, with regard to the Sicily-Northern Italy traffic, the model has pointed out that the 70% of the operators would opt for the Ro-Ro transport and, amongst these ones, the carriers demanding the services of a logistic terminal would correspond to the 49% of the whole sector; furthermore, in the remaining 30% of the cases, for the most part (25%), freight would be transported by road and handled by a logistic terminal; consequently only the 5% of the total would choose the traditional road-based mode. In the

Tables 6a, 6b, 6c: Truckers' mode choices in case the port of Palermo accessibility were improved.

O-D Link: Caltanissetta - Milano (Northern Italy)						
	Time(hours)	Cost (10^3 euros)	Damage	LT	P_{choice}*	Difference**
Ro-Ro	30.86	1.08	0	0	21.20%	0.27%
Ro-Ro+LT	34.86	1.01	0	1	49.59%	0.63%
Road	24.28	2.00	1	0	4.87%	-0.15%
Road+LT	28.28	1.46	1	1	24.34%	-0.75%
O-D Link: Caltanissetta - Perugia (Central Italy)						
	Time(hours)	Cost (10^3 euros)	Damage	LT	P_{choice}*	Difference**
Ro-Ro	25.46	1.09	0	0	16.18%	0.30%
Ro-Ro+LT	29.46	0.97	0	1	41.14%	0.76%
Road	18.91	1.45	1	0	8.55%	-0.21%
Road+LT	22.91	1.04	1	1	34.13%	-0.85%
	O-D Link: Caltanissetta - Potenza (Southern Italy)					
	Time(hours)	Cost (10^3 euros)	Damage	LT	P_{choice}*	Difference**
Ro-Ro	23.46	0.87	0	0	8.86%	0.27%
Ro-Ro+LT	27.46	0.79	0	1	21.13%	0.63%
Road	7.94	0.87	1	0	17.37%	-0.22%
Road+LT	11.94	0.64	1	1	52.64%	-0.67%

* Model-based choice probability.
** Computed in per cent points, with regard to the reference scenarios of Tables 5a, 5b, 5c.

case of links between Sicily and the other areas (Central and Southern Italy), for the use of a logistic terminal, the estimations show a global incidence of 70-75%; on the contrary, the role of the Ro-Ro option severely decreases.

The Ro-Ro traffic generated and attracted by Western Sicily is mostly organized by the port of Palermo, in the form of a mixed traffic (freight and passengers). However, this port can be considered a critical node of the regional transport network because of its low accessibility. Therefore, through the calibrated mode choice model, a comparative analysis has been executed, on the ground of effectiveness, about two projects for improving the port accessibility:

The implementation of the General Urban Public Transport Plan of Palermo to mitigate the urban traffic congestion, in relation to which the authors have estimated a 0.5 hour time saving for truckers covering the urban routes connecting with the port[7] (see Tables 6a, 6b, 6c).

The development of the Ro-Ro services supplied by the near port of Termini Imerese for moving truck traffic away from Palermo, by increasing the service frequency and the availability of Ro-Ro docks and port spaces. Such an action would imply for truckers a 1.16 hour time saving, also thanks to a throughway that connects the hinterland of Termini Imerese with its port bypassing the urban traffic (see Tables 7a, 7b, 7c).

As emerges from the preceding tables, the specialization of the port of Termini Imerese in Ro-Ro services, according to the port system logic, entails a slight growth of the Ro-Ro freight transport market share, in comparison with the port of Palermo accessibility improvement case. Such a finding requires investments for Termini Imerese to support Palermo in organizing commodity flows, rather than to become a transport node specialized in Ro-Ro freight traffic utilities.

Tables 7a, 7b, 7c: Truckers' choices if the Ro-Ro services at the port of Termini were upgraded

O-D Link: Caltanissetta - Milano (Northern Italy)						
	Time(hours)	Cost (10^3 euros)	Damage	LT	P_{choice}*	Difference**
Ro-Ro	30.18	1.08	0	0	21.56%	0.63%
Ro-Ro+LT	34.18	1.01	0	1	50.43%	1.47%
Road	24.28	2.00	1	0	4.67%	-0.35%
Road+LT	28.28	1.46	1	1	23.34%	-1.75%
O-D Link: Caltanissetta - Perugia (Central Italy)						
	Time(hours)	Cost (10^3 euros)	Damage	LT	P_{choice}*	Difference**
Ro-Ro	24.78	1.09	0	0	16.59%	0.70%
Ro-Ro+LT	28.78	0.97	0	1	42.16%	1.78%
Road	18.91	1.45	1	0	8.26%	-0.50%
Road+LT	22.91	1.04	1	1	32.99%	-1.99%
O-D Link: Caltanissetta – Potenza (Southern Italy)						
	Time(hours)	Cost (10^3 euros)	Damage	LT	P_{choice}*	Difference**
Ro-Ro	22.78	0.87	0	0	9.23%	0.63%
Ro-Ro+LT	26.78	0.79	0	1	22.01%	1.51%
Road	7.94	0.87	1	0	17.06%	-0.53%
Road+LT	11.94	0.64	1	1	51.71%	-1.61%

* Model-based choice probability.
** Computed in per cent points, with regard to the reference scenarios of Tables 5a, 5b, 5c.

Tables 8a, 8b, 8c: Truckers' choices if the Ro-Ro utilities at the port of Termini Imerese were upgraded and telematic services were introduced.

O-D Link: Caltanissetta – Milano (Northern Italy)						
	Time(hours)	Cost (10^3 euros)	Damage	LT	P_{choice}*	Difference**
Ro-Ro	30.18	1.08	0	0	21.03%	0.10%
Ro-Ro+LT	33.68	1.01	0	1	51.56%	2.61%
Road	24.28	2.00	1	0	4.57%	-0.45%
Road+LT	28.28	1.46	1	1	22.84%	-2.25%
O-D Link: Caltanissetta - Perugia (Central Italy)						
	Time(hours)	Cost (10^3 euros)	Damage	LT	P_{choice}*	Difference**
Ro-Ro	24.78	1.09	0	0	16.23%	0.35%
Ro-Ro+LT	28.28	0.97	0	1	43.27%	2.89%
Road	18.91	1.45	1	0	8.11%	-0.65%
Road+LT	22.91	1.04	1	1	32.39%	-2.59%
O-D Link: Caltanissetta - Potenza (Southern Italy)						
	Time(hours)	Cost (10^3 euros)	Damage	LT	P_{choice}*	Difference**
Ro-Ro	22.78	0.87	0	0	9.11%	0.52%
Ro-Ro+LT	26.28	0.79	0	1	22.78%	2.29%
Road	7.94	0.87	1	0	16.89%	-0.70%
Road+LT	11.94	0.64	1	1	51.21%	-2.11%

* Model-based choice probability.
** Computed in per cent points, with regard to the reference scenarios of Tables 5a, 5b, 5c.

Moreover, in the Termini Imerese port development case, the authors have quantified also the impact, on the waste of time at the port, of introducing innovations like electronic ticket and telematic management of document flows. Thanks to meetings with the representatives of some important consortia of Sicilian truckers that have implemented innovative forms of interacting with port operators (agreements to minimize the time spent for buying tickets and to pay reduced fares), a 0.5 hour saving in the time spent at the port has been assessed, which implies a further rise in the short sea shipping competitiveness, as reported in Tables 8a, 8b, 8c.

CONCLUSIONS AND FUTURE STEPS

An interesting output of the model calibration process consists in the positive coefficient for attribute LT, an explanatory variable quantifying the impact of using a logistic terminal on the road mode and the Ro-Ro one; such an outcome can be interpreted as the positive role perceived by Sicilian carriers for the availability of a logistic terminal, that could be ascribed to some ben-

efits emphasized by the authors during the interviews: the possibility of being informed about the current position of the cargo and the opportunity of consuming, within the same area, several services such as those ones provided by bars, restaurants, hotels, repair shops, petrol stations, banks, etc.

Future steps of the research consist in the following activities:

— Investigating the effects on mode choices of attributes relating to Sicilian haulers like the firm size, the chiefly conveyed commodity, the use of semi-trailers.

— To minimize errors in predictions, combining with *SP* data the *RP* observations on the modal split between the road mode and the Ro-Ro one, that have been collected during the *SP* survey trough the "typical journey "section of the questionnaire.

ENDNOTES

1. Mainly load factor and route optimization services.
2. If two block variables were considered, the possible levels of the interaction between themselves would be four: low-low; high-high; low-high; high-low.
3. For the final design, the number of decision contexts is calculated by raising the number of levels to the number of the "not confounded" attributes power.
4. After 4.5 hours of driving, truckers are obliged to stop for 45 minutes. After 10 hours of travelling, truckers are forced to stop for a period depending on the nature of freight. Moreover, the time spent for crossing the Straits of Messina has been quantified at about 1 hour.
5. The considered fares excludes the value added tax and the cost of the additional services.
6. During the interviewing phase, the authors have found that the travel time and the transport monetary cost are the most important variables explaining truckers' mode preferences.
7. This plan requires the development of the urban railway transport system and three new tram lines serving the outskirts of Palermo. Thanks to such interventions, one could forecasts a rise in the average speed of the ways to the port from the 7 km/hour level to the 18 km/hour one.

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MODELO DE DEMANDA DE TRANSPORTE MARÍTIMO PARA EVALUAR ACCIONES POLÍTICAS EN EL SSS DE SICILIA

RESUMEN

El presente artículo describe un proyecto de investigación en el que los autores desarrollan una herramienta de modelización que sirva de apoyo a las acciones llevadas a cabo en Sicilia por los políticos, para favorecer el *transporte de cabotaje*. En particular, con la finalidad de simular la división modal de la demanda del transporte de mercancías se ha calibrado un modelo *nested logit* a través de una encuesta de *preferencias declaradas* (*stated preference*, *SP*) realizada a 33 empresas sicilianas relativas al sector del transporte de mercancías por carretera. El modelo resultante se ha aplicado en la parte occidental de Sicilia para evaluar la eficacia de algunos escenarios que promuevan el *transporte de cabotaje*.

METODOLOGÍA

Los autores han desarrollado y estimado un modelo *nested logit*, a través de una encuesta de preferencias declaradas, para simular el comportamiento de los transportistas sicilianos en su elección ("carretera" vs. "Ro-Ro"), tomando en consideración la posibilidad de utilización de los servicios de las terminales logísticas (incremento del factor de carga y los servicios telemáticos) que actualmente no están disponibles en Sicilia.

Bajo la forma de un experimento de *SP* se ha presentado, a la muestra de personas que debe responder el cuestionario, un conjunto de escenarios de elección que presentan diferentes alternativas, caracterizadas por algunos atributos que varían de acuerdo a un número fijo de niveles, en el que se les pide que expresen sus preferencias (no necesariamente teniendo que elegir entre diferentes alternativas).

Para analizar la elección del modo de transporte por parte de los transportistas sicilianos, se han seleccionado los siguientes atributos: precio en euros de los servicios de transporte puerta a puerta, para un embarque promedio de 17.5 toneladas (tamaño del envío para las conexiones origen-destino de largo recorrido que tienen lugar en Sicilia); tiempo de viaje programado (horas); frecuencia de los servicios (semanales); confianza en términos del riesgo de sufrir retrasos (alta, baja); seguridad como el riesgo que corren los productos de ser dañados (alta, baja). En los casos considerados ("carretera", "Ro-Ro", "carretera + terminal logística", "Ro-Ro + terminal logística"), los niveles de los atributos empleados se han determinado a través de una base de datos referente a una muestra de conexiones origen-destino que tienen lugar en Sicilia (véase la Tabla 1).

Los escenarios de elección resultantes de combinar los niveles mostrados son 128: este es un conjunto de elección muy amplio para mostrar a los políticos, de manera que se han reducido a dos grupos con 8 alternativas de elección, para ser presentados a dos grupos diferentes de personas que los respondan, a través de la utilización conjunta de dos técnicas de diseño experimental, diseño factorial fraccionario y diseño de bloques (véase la Tabla 2).

La muestra de entrevistados consiste en 33 empresas sicilianas de transporte de mercancías por carretera. Como se estableció con anterioridad, las preferencias de los transportistas sicilianos se han modelizado a través de la formulación *nested logit*. En detalle, el proceso resultante de decisión se ha representado de acuerdo a una aproximación secuencial: hay una primera etapa de elección entre las opciones de "mar" y "tierra"; y en la segunda fase, bajo los dos casos ya mencionados el político considera la posibilidad de utilizar una terminal logística. Para estimar los parámetros del modelo, los autores han adoptado el Alogit 4.2 para procesar las 264 observaciones de elección resultantes de las entrevistas. La Tabla 3 muestra los coeficientes de los atributos de la función de utilidad que son estadísticamente significativos al utilizar el programa Alogit 4.2 para la estimación del modelo.

El valor resultante del tiempo es de aproximadamente 60 euros por hora, resultado que concuerda con una encuesta reciente a nivel europeo (CSST, 2005) sobre el coste por hora del transporte de mercancías por carretera (peaje, consumo de combustible, desgaste y desgarro de los neumáticos, mantenimiento, depreciación, impuestos).

CONCLUSIONES

El modelo calibrado *nested logit* se aplicó en Sicilia occidental para evaluar la eficacia de algunos escenarios que promuevan el transporte de cabotaje.

En detalle, se han estimado los tiempos de viaje y los costes monetarios de los diferentes modos de transporte con respecto a los proyectos a favor del transporte de cabotaje y a las diferentes conexiones entre Sicilia y el resto de Italia, cuyo origen se encuentra en la provincia de Caltanissetta (seleccionada debido a su posición baricéntrica). En primer lugar, utilizando una encuesta a nivel nacional llevada a cabo por los autores en las terminales logísticas, se ha utilizado el modelo para predecir el comportamiento de elección de los transportistas sicilianos si la región de Sicilia estuviera dotada de terminales logísticas. De esta manera, considerando el tráfico entre Sicilia y el norte de Italia, el modelo señala que el 70% de los operadores optaría por el transporte Ro-Ro y que dentro de éstos, un 49% de las compañías demandarían los servicios de una terminal logística; además, en el 30% de los casos restantes, para la mayoría (25%), la mercancía debería ser transportada por carretera y manipulada en una terminal logística; en consecuencia sólo un 5% del total elegiría el modo tradicional de transporte por carretera. En el caso de las conexiones entre

Sicilia y otras regiones de Italia (centro y sur), para el uso de una terminal logística, las estimaciones muestran una incidencia global del 70-75%; por el contrario, el papel de la opción de Ro-Ro se ve severamente reducido.

El tráfico de mercancías de transporte intermodal marítimo-terrestre generado y atraído en la parte occidental de Sicilia es en gran medida manipulado en el Puerto de Palermo. Sin embargo, este puede ser considerado como un punto crítico de la red de transporte regional debido a su baja accesibilidad. Por tanto, a través del modelo calibrado de elección modal, los autores han realizado un análisis comparativo de la eficacia de dos proyectos para mejorar la accesibilidad al puerto: la implementación del Plan General de Transporte Urbano en Palermo para mitigar la congestión de tráfico urbano, en relación a este punto, los autores han estimado un ahorro de 0,5 horas para los transportistas que cubren las rutas urbanas que conectan con el puerto; desarrollar las instalaciones y los servicios de Ro-Ro del puerto cercano de Termini Imerese, lo que supondría un ahorro de tiempo para los transportistas de 1,16 horas en el acceso al puerto, gracias a una autopista de peaje que conecte con el puerto evitando el tráfico urbano. Además, en los dos casos, los autores han cuantificado también el impacto que supondría, en términos de tiempo perdido, el introducir servicios telemáticos avanzados para organizar los flujos de documentación. Teniendo en cuenta los escenarios analizados, se ha demostrado que la especialización del Puerto de Termini Imerese en servicios de Ro-Ro, de acuerdo a la lógica del sistema portuario, es la mejor solución para promover la competitividad del transporte de cabotaje.