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**Conference Paper**

## Improving Accessibility of Portuguese Coastal Regions

39th Congress of the European Regional Science Association: "Regional Cohesion and Competitiveness in 21st Century Europe", August 23 - 27, 1999, Dublin, Ireland

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# ERSA 39<sup>TH</sup> EUROPEAN CONGRESS 1999

## Session: Accessibility and the Atlantic Arc

### Title: Improving Accessibility of Portuguese Coastal Regions

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## 1. Introduction

The Portuguese coastal area, with a densely populated width of about 60 km and an extension of roughly 400 kms, from Braga to Setúbal, contains more than 7.5 million inhabitants and the large majority of the developed economy of the country.

It is one of a few interesting dense corridors in Europe outside the “blue banana” but it still is seen by many as a very **peripheral region**. This is certainly due to the fact that it is located at the south-west extreme of Europe, and with Madrid as the only large conurbation located less than 800 kms away.

In a period where location of many activities near the end of the value-added production chain has to be made in places close to the markets, being peripheral means losing the chance to host such activities.

This paper exploits some alternative possibilities for improvement of **accessibility of this coastal area**, and with it for an increased role in Europe’s polycentric model of spatial development.

The study of such alternative possibilities is supported by two main tasks, which are:

- Analysing the accessibility of Portuguese coastal regions in the European context by comparing the accessibility of Portuguese and Spanish regions at the NUTS II level;
- Analysing coastal shipping as a valid alternative for improving accessibility of Portuguese coastal regions.

The methodology that supports this study is based on a revision of the concept of accessibility:

Accessibility is defined as a measure of proximity to potential partners, and two types of measure are used, the first one based on population as an indicator for general-purpose interchange (demographic accessibility) and the second based on the GDP of the regions concerned (economic accessibility).

This concept is explained with more detail in section 2.1 below.

## 2. Accessibility and Periphery

Accessibility has generally been defined as some measure of spatial proximity to human activities. Essentially it denotes the ease with which activities may be reached from a given location using a particular transportation system. It is a concept often used with a variety of meanings and for which no unique, universally accepted, definition has been made, even in the restricted domain of territory orientated sciences.

It is recognised that our displacements are mostly motivated by the activities we want to carry out at the place of destination, and in general we accept to endure longer travelling times in order to accomplish more important (i.e. less common) things (Viegas, 1998, p.2). For each set of activities of a similar level of importance, there will be a maximum value of overall time we accept to spend for their realisation (including the time for round trip plus the time for activity itself).

On the other hand, the human mobility is constrained by its 24-hour cycle, and its breaks for meals and sleep.

These two facts lead us to consider that **accessibility must be seen as a measure of potential of opportunities for interaction (interplay) conditioned by their equivalent maximum acceptable overall time**, which might be specific to a certain motive (type of interplay) or generic (a wide range of motives).

This potential always has to do with the difficulty of reaching the *other* (or any one of a set of *others*), as well as frequently, but not always, with the size of that *other*. If it is concerned with a specific motive, the size of the other is usually measured by its supply of the functions or services we are looking for, e.g. square meters of commercial floor space, number of concert seats, etc. If it is dealing with a generic set of motives, size is normally represented by the population.

There are two main dimensions that influence accessibility:

- my location with respect to the others (geodistance);
- the ease of connection between my place and those other places.

This ease of connection is represented by several variables, key among them being the speed of displacement (which leads to travelling time when considered jointly with distance). Other important variables for this are frequency of service, price and flexibility of travelling times.

If we have some concern for the problems of peripherality, then our intervention must be in order to ensure that the second dimension does not aggravate the first, and if possible should even compensate it.

**Periphery** in economic terms is not the same as in geographical terms. Areas located in the edge of continents are geographically peripheral but certainly not so in economic terms if they include or are near to large quantities of population and activity.

In economic terms, a peripheral region is simply a region with comparatively small quantities of population and activities located between 3 hours and 2 days away from it, especially up to one day (Viegas, 1998, p.3).

## 2.1 Proposed Indicators for Measuring Accessibility

The proposed methodology for measuring accessibility reflects results of transport investments in the two main dimensions:

- Demographic Accessibility;
- Economic Accessibility, i.e., potential gain of economic efficiency by reduction of transport costs in referred imports and exports.

Both these indicators express the number of “partners” that can be reached (from each basis region) in a pre-specified travel time threshold associated with the 24-hour cycle of human activity.

For demographic accessibility the population (inhabitants) living in each region within reach is used as the weight of each partner region, whereas for economical accessibility the gross domestic product (expressed in monetary units) play that role.

$$Q^D(T_k) = \sum_{j=1,N} P_j, \text{ if } t_{i,j} \leq T_{i,j} \qquad Q^E(T_k) = \sum_{j=1,N} GDP_j, \text{ if } t_{i,j} \leq T_k$$

Table1.  
where:

- $Q_{Tk}$  is the indicator of demographic and economic accessibility, respectively;
- $T_k$  is the pre-specified travel time threshold;
- $i$  is the basis region;
- $j$  are the destinations reached;
- $t_{i,j}$  is the travel time;
- $P_j$  is the total existing population of destination  $j$ .
- $GDP_j$  is the gross domestic product of target destinations  $j$ .

Table1. As it can be observed in the next chapter some calculations of accessibility are made in order to analyse the number of opportunities that can be reached from a geographically peripheral regions such as the NUTS II of the Iberian peninsula. Of course, a geographically peripheral country as Portugal, which is located at the edge of a continent is more likely to be economically peripheral since it can only count on neighbours from one side (on the other side a significant width of water exists before another landmass can be reached).

Both indicators should be measured for passenger and freight transport, taking into consideration the pre-specified travel time thresholds of each one.

The travel time thresholds refer to round trip and single trip for passenger and freight transport, respectively. This merely reflects the judgement made by those who decide to make the transport. Persons are supposed to come back to the point of origin and count the total round trip time as their cost, but freight does not come back and if there is a professional organisation involved in transport production, they (not the client) must find the demand for the following days of that rolling stock;

### **3. Accessibility of Portuguese Coastal Regions in the Context of Iberian Regions (NUTS II)**

#### **3.1. Present Situation**

##### **3.1.1 Main Assumptions**

This section describes the main problems found and the main assumptions made in the calculation of demographic accessibility.

As we are working at the European scale, some problems related with the availability of data for some European regions have constrained the calculation of the proposed indicators, implying some simplifications.

In the context of a comparison between coastal shipping and road (see chapter 4), freight transport is the one that makes more sense to analyse and so the calculations were made using the pre-defined travel times thresholds for freight transport.

Part of the data used in this exercise was provided by the Transport Information System (TIS)<sup>1</sup> developed in the framework of the CODE-TEN<sup>2</sup> project. Some additional data related to population had to be included in this TIS.

The regional subdivision adopted – NUTS II - has taken into account that regional subdivision should correspond to national administrative units and be the same for all European countries, thus assuring a minimum degree of consistency. However, at the same NUTS level, different sized areas can be found. Moreover, in Eastern European countries no common regional classification exists yet. In this last case, comparable administrative units have been selected in that project and adopted here.

It should be noted that the fact of a NUTS II being reached in a certain travel time from a basis region, doesn't mean that it is accessible in its whole dimension, i.e., it doesn't imply that all of its population is equally accessible. So, we have considered the European cities as destinations instead of European NUTS II. Consequently, some assumptions were established:

- The majority of the population of each region is located in the cities;
- The amount of population outside the cities is spread over the countryside as a “blanket” of uniform density within that NUTS II region.

From above we derived the re-scaling of the population of the cities in the database so that the sum of their populations would equal the total population of the region.

The cities considered are the most populated cities (4 or 5) of each of the NUTS II regions following countries: Albanian; Austria; Belgian; Bulgarian; Czech Republic; Denmark; Spain; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Luxembourg; Netherlands; Poland;

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<sup>1</sup> The TIS provides information at regional or national level for networks.

<sup>2</sup> CODE-TEN (Strategic Assessment of Corridor Developments, TEN Improvements and Extensions to the CEEC/CIS ST-97-SC.2090) – Project funded by the European Commission under the transport RTD Programme of the 4<sup>th</sup> framework programme.

Portugal; Rumania; Sweden; Switzerland; United Kingdom. The total number of cities considered is 1285.

Given the overwhelming dominance of road transport for land transport within Europe, as well as its higher speed than rail for freight transport, we have only considered road transport in our computations of accessibility.

The database used for the road network only included maximum legal speeds for private cars. In order to convert them for HGV's it was intended to correct that value through a formula of that would consider the sinuosity of the road link, the speed limit itself and (whenever available) the relation between Average Daily Traffic and type of road (as a proxy for congestion). The time available for the presentation of this paper did not allow to go through this process with the necessary caution, so it was decided instead to use as the speed for HGV's simply 70% of the speed limit for private cars. This relatively high percentage was thought adequate because we are dealing with a database including almost exclusively links of motorway standard or similar.

The travel time threshold should be affected by the limit of 9 hours driving per day (extended to 11 hours driving in one exceptional day, or 20 hours for two days, but not as a daily average), and so the travel time thresholds used are related with that value:

Driving Time Threshold (hours)	4,5	9	11	20	27	36	45	72
Travel Time Threshold (days)	0,5	1	1 <sup>+</sup>	2	3	4	5	8

### 3.1.2 Analysis of the Results Obtained for Demographic Accessibility Indicator of Iberian NUTS II

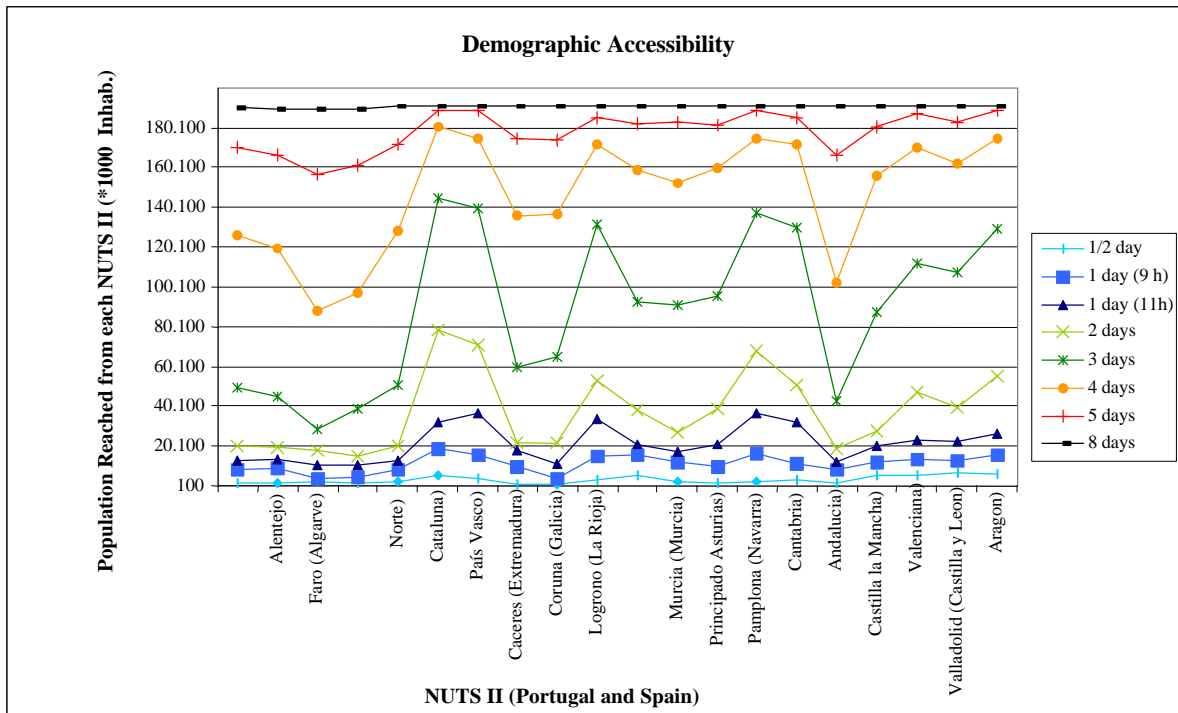
The goals of this section are:

- In a first approach, to obtain the ranking of accessibility indicators presented in the previous section for the NUTS II of the Iberian peninsula;
- In a second approach to analyse the above results having the Portuguese coast as the focus of such analysis.

The demographic accessibility indicators are calculated by taking the main cities of each of the Portuguese and Spanish NUTS II regions as the bases and the 1287 European cities referred above as the destinations to reach in the pre-specified travel time thresholds.

According to the assumptions and simplifications reported in section 4.1, the minimum travel time needed to reach each of the considered European cities from each seat of the NUTS II was calculated, and after that the total population reached in the pre-specified travel time threshold was determined.

The following graphic displays the results obtained from those calculations:



**Figure 4.1 – Demographic Accessibility of Portuguese and Spanish NUTS II**

### Comments on the Results

- For the limit of 8 days the differences between NUTS II are not relevant, i.e., the total population reached is almost the same independently of the basis region considered. However, these differences are still significant up to a time threshold of 4 days.
- In the context of Iberia, the Portuguese NUTS II present (in general) low values of demographic accessibility, i.e, the populations reachable in the pre-specified travel times threshold are lower than for most Spanish regions.
- Generally, the most significant differences between Portuguese and Spanish regions are visible from 2 days on, with 3 days as the travel time threshold for which the most notable differences are observed. Although still visible, these differences become smaller from 4 days on.
- In Spain, the highest values are obtained for the regions closer to the French border, whereas the lowest are for those close to the Portuguese border.

### **3.2 Improving Accessibility: two synergetic goals**

The purpose of the accessibility reinforcement is, at first, to identify modal points or access points where we can **find the secondary networks that should be developed and improved in order to allow their interconnection to the main networks as Trans-European Networks (TEN-T)**. This identification must be made in a straight co-operation with the regions.



These access points can be ports, airports or cities where translations are located. In order to develop the **intermodality** train/sea, road/sea, train/air, these cities could develop common projects.

It would be necessary to give priority, by applying the periphery criteria, to projects with the purpose of approaching peripheral zones, with a low populational density, to new emerging poles, located in their relative neighbourhood: urban concentrations of medium importance, often coastal cities in other countries, around which a high concentration of economic activity is located.

It is recognised that the density<sup>1</sup> of one region is a critical issue for geographical peripheral regions in the context of minimisation of their economic peripherality. This can be obtained in both ways (Viegas, 1998, p.3):

- Improving the lower levels of accessibility by an **internal densification**, through the development of the links at the local network of cities<sup>2</sup>;
- Increase of gateway functions, by an **external densification**, i.e. generating a “transit” demand that is not generated in the region but also contributes to reaching the thresholds that allow use of more performing modes of transport or increases of service frequency in its relation with the “hinterland” regions. The role of maritime transport assumes particular emphasis in this respect.

It is a fact that different transport modes have different requirements of density of flow to reach their level of economical feasibility, but also different curves of cost increase in response to increasing flows. Thus, a long distance may be compensated by a fast transport connection, the mode being chosen according to the density of flow.

Intermodal transport solutions try to address this variety of ideal modes with respect to the density of flow and required speed, by integrating demands (i.e. adding densities) from different origins and destinations in a very complex network that provides in each elementary link the best mix of modes.

The combination and integration of different transport modes and the development and improvement of interconnection nodes for intermodal platforms are two essential directives of Tran-European Networks.

Intermodality is an essential component of the European Union’s Common Transport Policy for sustainable mobility. Its objective is to develop framework for an optimal integration of the different modes and utilisation of their capacities, so as to enable an efficient use of transport system through seamless, customer-oriented, door-to-door services favouring innovation and competition between transport operators. (European Commission Communication, COM (97) 243, final)

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<sup>1</sup> The importance of density is simply explained by its association with concentration of demand, which facilitates either the introduction of stronger frequencies of service or even the application of more performing technologies for transport at a given distance.

<sup>2</sup> Although a very relevant topic in practice, this cannot be checked with the data representation adopted for this paper, as we have supposed all population concentrated in the larger cities.

Articles 129 b and c of the Treaty on the European Union govern the development of the trans-European transport network (TEN-T). **It requires the EU to promote the interconnection and interoperability of national networks and access to them, taking into account the need to link island, landlocked and peripheral regions of the Union with its more central areas.** The aim is to enable citizens of the Union, economic operators and regional and local communities to derive full benefit from the internal market. Clearly interconnection, interoperability and TEN-T optimisation in general cannot be achieved if ports are not included in the equation as a crucial element of an integrated European transport network.

The geographical shape of Europe, with so many peninsulas and islands of significant dimensions creates a strong basis for the foundation of short-sea-shipping. The fact that some of Europe's natural gateways with respect to intercontinental maritime transport are located in peripheral regions gives added importance to short-sea-shipping in this perspective of a more balanced spatial development in Europe.

### 3.2.1 The role of Ports in the Trans-European Network

Trans-European Transport Networks (TEN-T) have been conceived and adopted as key instruments in the process towards the Internal Single Market, as it was understood that without such high infrastructure support, both on quality of alignment and increased capacity, transport costs would be too high and contestability in many markets would be significantly reduced. Later on, their role in the cohesion policy was also recognised, as an instrument to facilitate integration of people and companies from these regions into the main stream European stages and processes.

Initially, the linear nature of road and railway networks – and the corresponding ease of drawing them on a map – has led to a concentration of attention on these two modes of transport. Sea ports and airports tended to be considered as facilities which in many cases certainly could have to receive capacity or quality upgrades but would not require the level of massive investment (and thus demand the level of political dispute for money) that those linear infrastructure pieces would.

As the European interest of these investments was clear, it was expected that EU financial contribution for their construction would be greater, and this has raised the appetite of many national and regional governments to have their “bit” included in the official configuration of these networks. The consequence has been a successive increase in the extension of these networks, accompanied by the inevitable blurring of any realistic perspectives for their construction in the short term. A set of priority schemes has been adopted in the Pan-European Transport Conference in Helsinki and small pieces are being constructed, but there is a growing feeling that the sense of proportions may have been lost.

As for the seaports, their inclusion in the TEN-T has been accepted in the meantime, but this has not led to significant changes in the way ports are receiving investment or are being managed. Still, it is clear that the role of short sea shipping in EU trade is sufficiently strong to justify that possible ways to increase their contribution to the roles underlying the very existence of the TEN-T be studied and subject to policy debate.

It seems obvious that an increase of the role of maritime transport for intra-European trade would require not only upgrading of some port facilities but especially an adaptation (dedication) of part of that infrastructure, a simplification of administrative and charging rules for the case of intra-EU

short sea shipping, and the setting up of regular links that take full advantage of these conditions and establish short sea shipping as a viable alternative to road transport for many connections between peninsular regions.

Only then, with streamlined terminal infrastructure and operations, and the provision of a set of regular and frequent lines connecting clusters of EU ports will it be adequate to speak of the maritime component of TEN-T. Until then, it is only a matter of political fight to get additional money from Brussels or notoriety for being nominated for inclusion in the Trans-European Networks.

**4. Potential of Coastal Shipping in the Accessibility Improvement of Portuguese coastal regions**

**4.1 The Competitive Position of Coastal Shipping**

The institution of short-sea-shipping as a mode that can compete in the transport market with other modes is a positive factor for the developing of the sector in a sustainable scenario of mobility and in the specific Portuguese case as a revitalisation factor of its maritime sector. Although there are good opportunities to get it, there are some threats that should not be forgotten.

The natural advantages and disadvantages of sea transport can be addressed as follows (VandeVoorde and Viegas, 1995):

<b>Natural Advantages</b>	<b>Natural Disadvantages</b>
Sea transport seems to be cost effective	Lower frequency of service for any pair of points, because of larger unit capacity
An increase of short-sea-shipping requires not too much additional infrastructure	Lower reliability of departure and arrival times due to variability of weather conditions
Sea Transport is environmental friendly, and economical concerning energy consumption	Higher risk of damage to transported goods
	Higher number of companies participating in the service supply

In other hand road transport, as a single mode alternative, has some characteristics that are very close to the requirements of the current transport market demand (just-in-time and door-to-door service). Moreover, European road transport became stimulated by enormous investments in road infrastructure. In spite of some opposition, based on congestion and environmental problems, the poor response from other modes so far has forced many governments to keep investing strongly on road networks of higher ranking to avoid damaging to their economy.

The competition question has to be taken between combined transport, including short-sea-transport, and single mode transport as road haulage.

In this context, a comparison between coastal shipping and road transport on the basis of travel time is made below.

#### **4.2 Main Ports for Container traffic: Lisbon and Leixões, and Sines in the future**

In this paper we compare transport by road and by coastal shipping for containers, as it is clearly the most significant flow that can switch between these two modes.

The last decade was characterised by a deficient supply of specialised service of Portuguese ports, which has been a constraint for the attraction of ships. The prevalence of conservative practices has been negatively reflected in the market share of Portuguese ports with respect to road transport.

Furthermore the maritime infrastructure concerning intermodal connection and crossing of urban areas around the ports is still a problem, especially in Lisbon and Leixões (just outside the city of Oporto) across which 99,6% of the Portuguese containerised cargo transported by maritime mode is moved.

Very recently (July 24<sup>th</sup>, 1999) a contract has been signed between the Portuguese government and the Singapore Port Authority to establish a main seaport in Sines (on the Atlantic coast, 150 kms south of Lisbon) as a point of transshipment for intercontinental routes, and also the possibility of transfer of containers for short-sea shipping lines. This will certainly establish Sines as the main Portuguese container port, at least for goods coming from / moving to other continents.

#### **4.3 Coastal Shipping vs Road Transport: a travel time comparison and consideration of shipping costs and values of time**

This comparison is based on the travel times needed by road transport and by combined transport (shipping and road) to reach the European cities considered in the section 3.1. starting from Lisbon. Given the scale of distances, most conclusions would be identical for the cases of the two other container ports in Portugal.

The main assumptions and simplifications assumed in this analysis are:

- We have considered the whole Spanish territory to fall within the domain of land transport (currently dominated by road), virtually out of possibility of competition for short-sea shipping from Portugal (there is some freight volume by ship in the statistics between Lisbon and Barcelona, but this is largely feeding for deep-sea ships);
- Contrary to road transport, transport by sea moves 24 hours a day, but the total transport time of this option needs consideration of transfer times at ports;
- For this transfer time we have used 12 hours for northern European ports and 24 hours for southern European ports (the latter are much less efficient);
- We modelled a multimodal network including these transfer links and “forced” the use of at least one sea link for computation of the shortest transport times from these two Portuguese cities to each of the European cities also covered in the “road-only” computation described above;

- The ports considered for this were the main ones along each of the coastal NUTS II or “equivalent” regions, both on the northern range (Atlantic Ocean, North Sea, Baltic Sea) and on the southern range (Mediterranean Sea);

For the total accessibility values by time threshold, the following table shows the comparative results by road and by sea (after discounting the Portuguese and Spanish populations, which we did not consider as within reach of the maritime alternative):

Time threshold (days)	Population accessible by road (millions)	Population accessible by sea +road (millions)	% effectiveness of sea+road
3	21.1	0	0%
4	79.2	5.3	7%
5	142.7	162.1	114%
8	171.3	172.6	101%

Of course, for the shorter transport times, the road gets a very strong advantage, which largely results from transfer times imposed by ports. These being more or less fixed (we assumed 24 hours for Lisbon and all other southern European ports, and 12 hours for northern European ports), they represent a large penalty when the actual transport time is small. However, when more days are allowed, continuous operation of ships, even if at lower speeds, catches up and eventually reaches equivalent (or even wider) areas than pure road transport.

The proportion of “catchment” (beyond the Iberian Peninsula) of maritime transport with respect to road transport is thus only 7 % for a total transport time up to 4 days, but for 5 days is already above that of road transport (with 114%), the values for 8 days being virtually equal as all the study area (European continent) is covered by both modes.

Still, the fact is that substantially lower costs of transport by sea invites reconsideration of this balance.

There is not much reference of value of time for freight across modes, although Dutch and British surveys have led to identical values for goods carried in international trade by road (in average about 41 ECU/h per truckload) (PETS 1998; de Jong 1996, ITS 1996).

One of these studies (de Jong 1996) also cites a Dutch value of time for rail freight that is 25% of that found for the road freight. On lack of additional evidence, we use the same value for sea-bound freight as that found for rail freight.

If we accept that in average one truckload will carry 20 ton. of goods the value of time of 2 ECU/ton/hour is obtained for freight transported by road, and that of 0.5 ECU/ton/hour for freight transported by ship.

The price paid on road transport is also substantially higher than that for transport by ship: although there is high variability depending on the organisation of driving (single driver, two drivers, relays, etc) and on whether the trip considered is an outbound trip or a return trip (from the point of view of the basis of the haulier) we can admit that a value of about 1.2 Euro/km is not far from average for Portuguese trade. With truck moving at speeds of about 75km/h, this is roughly equivalent to 90 Euro/h.

In shipping, the typical price paid for containers is much less sensitive to distance or travel time, given the relative weight of port operations and of the terminal land connections. Considering all these factors, we have come to the following approximate expression for price per 20 ft. container (roughly 10 ton. of payload) in a trip involving one Portuguese port at one end and a random European port :

$$P_{\text{ship}} = P_p + P_w + P_1 = P_p + 8.5 * N_{\text{waterhours}} + 60 * N_{\text{roadhours}} \quad (\text{in Euros/ 20 ft. container})$$

where:

$P_p$  is the price paid for port operations [taken as 170 Euro/ container in the north and 220 Euro / container in the South];

$P_w$  is the price of the waterborne part of the trip [taken as 8.5 Euro/ container per hour of navigation];

$P_1$  is the price of the terminal leg, made by land transport [for which we use an hourly value of 120 Euros per truck instead of 90 Euros, given the short distance involved];

So, for any destination, we have two alternatives of total cost (price paid for transport + value of time for the goods), that can be written as follows (values applicable for a load of 20 ton, roughly equivalent to 2 T.E.U., all prices in EURO):

$$C_{\text{road}} = 90 N_{\text{roadhours}} + 20 * V * N_{\text{totalhours}}$$

$$C_{\text{ship}} = P_{\text{ship}} + 20 * V * N_{(\text{water}+\text{transfer}+\text{road})\text{hours}} = \\ 2 P_p + 17 * N_{\text{waterhours}} + \\ 120 * N_{\text{roadhours}} + \\ 20 * V * N_{(\text{water}+\text{transfer}+\text{road})\text{hours}}$$

where:

$V$  is the value of time per tonne per hour, variable between 0.5 and 2.0, as we saw above.

The lower values of  $V$  will refer to goods that will only with difficulty bear to pay the price of road transport, whereas the higher ones will require substantial increases of quality from sea transport to consider a change. The interesting values will be those intermediate ones where modal shift is possible, and we have tested for values of  $V$  equal to 0.8, 1.2 and 1.6.

Of course, there are other factors in favour of road transport, like reliability and security of the cargo, but we have admitted that the disadvantage for shipping may be reduced in the near future thanks to increased use of electronics and telecommunications. Another key advantage of road transport is immediate availability, but here the recent developments in relation to Sines may also reduce the scale of this advantage.

The purpose of the exercise here is to estimate potential accessibility gains by considering the possible supply of the two modes as against those values estimated considering only road transport.

For those 3 different values of  $V$ , we have revised the accessibility calculations from Lisbon, considering now the Cost thresholds instead of Time thresholds. This leads to different time thresholds by mode for the same level of accessibility.

For instance, for a load of 20 ton. and using a value of  $V = 1.2$ , a time threshold of 3 days (72 hours, of which maximum 27 hours driving) is converted into a cost threshold of  $(90 \text{ Euro/truck/h} * 27 \text{ h}) + (20 \text{ ton} * 1.2 \text{ Euro/ton/h} * 72 \text{ h}) = 2430 + 1728 = 4158 \text{ Euro}$ .

So, for each value of  $V$  we have re-established the same road transport time thresholds as before, expressing them now as cost thresholds, and then run again the sea+land network to define the areas found within the same total cost thresholds.

The results of comparison of one mode versus the other are naturally very different from what was obtained considering the transport time alone.

If we compare the number of inhabitants of the areas (beyond the Iberian peninsula) within each of those thresholds from Lisbon we obtain the following table (for simplicity, only some thresholds are reproduced here):

Time threshold (days)	V = 0.8			V = 1.2			V = 1.6		
	Cost Thresh. (Euro)	Mill. inhab. reached	Mill. inhab. reached	Cost Thresh. (Euro)	Mill. inhab. reached	Mill. inhab. reached	Cost Thresh. (Euro)	Mill. inhab. reached	Mill. inhab. reached
		Road Alone	Sea + Road		Road Alone	Sea + Road		Road Alone	Sea + Road
3	3582	20.6	20.0	4158	21.1	0	4734	21.1	0
4	4776	77.3	118.6	5544	78.1	112.7	6312	87.5	106.9
5	5970	141.6	154.0	6930	142.3	151.1	7890	143.3	151.8
8	9552	171.3	171.3	11088	171.3	171.3	12624	171.3	171.7

If we read these values from left to right (growing values of Time), we see that the (generalised) cost thresholds corresponding to a certain number of days of transport are also growing, which also allows the catchment of the road mode to increase, especially for the 4 day range (an increase of 21% in catchment for an increase of time value from .8 to 1.6 Euro/ton/h).

For the sea+road mode, the movement is in the other direction, with catchment size decreasing, also with a particular significance for the 4 day threshold (a decrease of catchment of 10% for the same increase of time value).

The explanation is simple: as the value of time increases, for the same total time, generalised cost increases and road transport can get farther because it moves fast. On the contrary, sea transport is hampered because of its low speed and cannot go so far because of the “excessive” time bill it faces.

## 5. Conclusions

We see that sea transport is not an easy replacement to road transport in the time ranges that constitute the vast majority of trade, even if we consider only international trade.

However, for transport times of between 4 and 5 days (in transport from Portugal), it can reach volumes of population that are of the same order of magnitude as those reachable by road. This message is not significantly changed if we include not only travel time but also shipping price and value of time: the break even point in terms of population volumes within a certain generalised cost of transport still falls close to 5 days, and is not very sensitive to the variation of the value of time for the goods transported (in fact a proxy for the monetary value of those goods).

So, we see that to reach a considerable change in the accessibility level of peripheral regions like Portugal (taken here as accessibility for trade), it is not enough to count on an increased role for maritime transport except for relatively large distances, at least with the current practices in European Ports.

We have seen that a substantial part of the time penalty may be attributed to “dead” times at port terminals, occurring both on loading and unloading operations. Of course, the time to load and unload a ship may never be the same as for a truck, but substantial improvement should be made on the administrative steps associated with these transfers, possibly together with more sophisticated pricing practices, with discounts for those who can afford to sustain long dead times and increases for those who need to have a quick transfer of their containers.

If changes like these are introduced on the European short-sea shipping, there will be scope for a much greater contribution of maritime transport to European trade and to a more balanced presence of peripheral regions.

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