ANALYSIS OF THE EXTERNAL COSTS OF SELECTED SHORT SEA SHIPPING VESSELS AGAINST THE ROAD ALTERNATIVE

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ABSTRACT

According to the midterm review of the EU White Paper on Transport, Short Sea Shipping is expected to grow at a rate of 59%, in metric tones, from 2000 to 2020. We consider that the overall expected growth in freight exchanges is of 50% (also in volume) sea transport is one of the most feasible ways to reduce traffic congestion on European roads. However its clear adoption as a transport alternative has not been definitely carried out by several reasons. There are identified technical, administrative and legal reasons, but the society understands the maritime transport still as a slow and low efficient transport mode, not seen as a real alternative at all. As shippers has not find always the most satisfactory service nor the best price that could motivate a modal shift. There is the need for balance the infrastructures, using tariff principles based on the necessity for reflect the exact external costs generated by the different infrastructures, the EU published in 1998 the White Paper on Fair Payment for Infrastructure Use: A Phased Approach to a Common Transport Infrastructure Charging Framework in the EU COM (1998) 466. This article will analyze on selected multimodal transport chains, the pollutant emissions of different powered ships compared with the ones of their road alternative. These pollutant emissions will be translated to environmental costs, based on existing quantification databases. In some cases the maritime transport gets savings in those costs against the truck, what would justify a kind of environmental bonus to be used by the administration to promote the sea option. The paper will conclude briefly discussing how to best implement the bonus for getting a real transport mode balance.

KEYWORDS: Air pollution, External costs, short sea shipping, ecological bonus.

1. INTRODUCTION

The European transport policy is compromised to be a sustainable activity that will boost the economic activities in the whole Union. The pollutant emissions' reduction and a better equilibrium among different transport modes to reduce traffic congestion on the roads are the basic pillars of the mentioned policy. These factors are encouraging the public and private stakeholders to use more extensively the freight rail mode and of course the maritime alternative, in a constant search for the best solution. Most of the developed countries use a national net of roads to move freight, despite it being the most expensive, pollutant transport mode; maintaining the highest rate of fuel consumption per distance and cargo unit [1].

The maritime sector is one of the less pollutant ways in addition to the capacity of contributing to reduce the road congestion in Europe. Particularly, the short sea shipping is thought to be the quickest way to reach the sustainability goal. One of the cost advantages of ships over trucks and trains is lower fuel consumption, which depends on its relatively low speed [2]. But the question is that not all the transport modes assume the external costs that generate the infrastructures they use, what distorts the free competence and makes false the final prices and incentives for using other alternative and more efficient transport modes, from the economic, social and environmental, point of view.

This paper has been divided in three sections. Firstly, the definition of the environment regulations applied to transport policies and their external impacts. Secondly, the quantification and valuation of external costs on previous selected short sea shipping routes compared to road alternatives in SW Europe and finally, the proposal of an ecological bonus for the truck companies that would use the maritime alternative in selected routes.

2. THE SCENARIO

The European Union from the year 1998, published the White Paper on Fair Payment for Infrastructure Use: A Phased Approach to a Common Transport Infrastructure Charging Framework in the EU COM (1998) 466, where it clarified that the one uses the one pays and most of all the one pollutes the one pays. Initially it was proposed to base the dues affecting the vehicles of more than 12 metric tonnes of maximum payload, on the infrastructure marginal costs per kilometre and on the urban congestion marginal costs. The first tariff scheme for the infrastructures use, from different studies carried out within Europe like the DESIRE (2001), INFRAS (2004) and others, pretended to begin in Germany with an initial price of 0.17 €/km in the year 2003, applied to all vehicles and truck units with a maximum loading capacity exceeding 12 metric tonnes, passing through or delivering, goods in Germany. But after repeated delays did not begin up to the year 2005 with a proposed price of 0.124 €/km, during the year 2007 the average rate increased to 0,135 €/km and further revision would be done during October 2008. The amount of charges depends on the exact number of kilometers driven on paid motorway sections, a number of vehicle axes and an engine class as far as the emission of waste gas is concerned.

Not withstand, when seeing to the transport pollution generated external costs, we should remind that the European Union through its sustainable development strategy and the White

Paper on transport, has proposed a common application of measures to solve the environmental threats in the transport activity.

Regarding road transport we must come back at the time when the European Parliament adopted in 1988 the first Euro regulation, passing through Euro II, III, IV and followed up to now by the Euro V and VI regulations, being progressively stricter regulations on vehicle pollutant emissions, specially referred to particle emission and nitrogen oxides (NOx) limits. The Euro V will be instituted on the 1st of September of 2009 and establishes a decrease of 80% in the particles emission limits, which means the future fitting of particle filters in vehicles. The Euro VI regulation, will enter in force in 2014 and will pose stricter limits, with the aim to reduce the nitrogen oxides up to a 68% from the nowadays levels.

The maritime transport emissions are regulated mainly by the MARPOL Convention and some specific European regulations. The new regulations regarding the SO_2 and NO_x maximum emission levels will reduce this kind of pollutant's components, which will be maritime transport's weakest point in the future. Maritime transport is the responsible of the biggest volume of SO_2 into the atmosphere, among the entire transport sector, only to be compensated by means of reduced sulphur content fuels or cleaning exhaust gas systems. The maritime transport sulphur pollutant emissions, accounts only for the 6% to 12%, of the total anthropogenic emissions [3]. We must mention other factors affecting the rate of short sea shipping pollutant emissions such as the fleet age and the highest number of trips expected to be done.

Despite of this scenario, in 2000 about 44% of the total NOx emissions to the atmosphere in Europe were attributable to road transport, being for shipping about the 36% of the total NOx emissions in the EU – 15 countries [4]. The road transport is the main source of CO_2 emissions, contributing 91.7% to the EU transport greenhouse emissions. When including maritime shipping into the break-down of transport mode-related CO_2 emissions, it appears that maritime transport accounted in for only about the 6% of the total greenhouse gas emissions related to transport in Europe, and this justifies the interest for reducing the share of road transport.

The International Maritime Organization is expected to approve a set of comprehensive amendments revising the air pollution annex of the Marine Pollution convention and the associated mandatory Technical Code governing nitrogen oxide emissions from ships' diesel engines. The work was done by the BLG 12th session in February and presented in the MEPC 57th session. However an additional step has been passed in October 2008, before the adoption and further entry in force 16 months later in March 2010.

Although the balance of emissions in the atmosphere of maritime transport is the most favourable, this is not true of the emissions from the road. This fact justifies the support actions to multimodal chains with marine sections based on short sea shipping links, as a way to reach a more sustainable mobility within Europe. Therefore, maritime transport has a clear environmental advantage over other modes of transport. In addition there is less congestion, accidents and noise costs at sea, making the maritime mode a better option [5].

But a transports policy only based on the tariff measures will not provide alone the desired modal shift because the user together to the measures should perceive the alternative transport modes as efficient and quality choosing. Altogether the administration should collaborate to improve the multimodal infrastructures as the ones like the port and rail multimodal links or for example to easing or speeding up all the documentary dispatch processes that freight suffers in the maritime transport.

3. STUDY OF THE MARINE ALTERNATIVE

Due to the patent rail limitations in a midterm, because the high coordination level needed among all the involved countries, in terms of investments, engineer licenses mutual recognition, unification of signal systems or the standardisation of electrical power nets, the short sea shipping is seen as the best placed alternative in a short term view.

The concept of short sea shipping is defined in the COM (1999) 317 final “The development of short sea shipping in Europe” document, as the *transport by sea of goods and passengers, between ports geographically placed in Europe or between those ports and other ones located in coastal countries of the closed seas surrounding Europe*, this means that it integrates the following aspects:

- Roll On Roll Off traffics
- General cargo traffics, including containers
- Liquid and solid bulks even neobulk traffics
- Passengers transport
- Feeder services

In this sense, we have selected five examples from a complete study of the short distance multimodal transport lines calling at one port in the Iberian Peninsula. These lines were identified in previous studies as INECEU (2005) and ANTARES (2007), carried out by Transmar research group for the Spanish transport Ministry [7]. All of them are calling at

Spanish peninsular ports linking different destinations. It should be noted that in the table are the full multimodal chains, but the study has been done only from port to port. (Table 1)

Route	Origin	Loading port	Discharging port	Destination
Route 1	ZAL Azuq. of Henares	Valencia	Naples	Naples
Route 2	ZAL Barcelona	Barcelona	Civitavecchia	Rome
Route 3	Zal Alicante	Alicante	Genoa	Milán
Route 4	CETABSA Burgos	Tarragona	Genoa	Milán
Route 5	CTB Benavente	Gijón	Hamburg	Berlín

Table 1: Routes obtained from the ANTARES study. Source own.

Keeping in mind the above mentioned multimodal routes, the methodology of study was the following:

a) As the operational costs are not the intention of this study, we focused mainly in the external costs. The external costs were divided in two cost categories:

Environmental external costs: local air pollution, global warming and acoustic pollution.

Non environmental external costs: accidents and road congestion.

b) In order to estimate the impact of the evolution of emissions from different transport modes, the following scenario will be considered, in the road sector the Euro IV standard (enforced for new trucks in 2006 and showed in table 2) and for maritime transport a supposed decrease of 10% in all the emissions except for S, SO_2 and NO_x.

Emission factors	ROAD			SSS
	Euro III	Euro IV	Euro V	
SO_2 (g/kg fuel)	0,8	0,114	0,114	30
NO_x (g/kg fuel)	56,25	28,125	18,75	19,36
CO (g/kg fuel)	6,7	5,75	5,75	8,1
Nm-VOC (g/kg fuel)	2,9	2,316	2,316	2,466
PM (g/kg fuel)	1,8	0,45	0,45	6,84
CH_4 (g/kg fuel)	0,3	0,095	0,095	0,099
CO_2 (g/kg fuel)	3323	3323	3323	2853
S (g/kg fuel)	0,35	0,05	0,05	15

Table 2: Emission rates for the diesel Euro III, IV and V road and sea, transport. Source own, based on ICF model from REALISE, 2005.

c) In each route the sea and road possibilities were analysed, distinguishing in the marine section, among services carried out by conventional, fast conventional and high speed ships. The ships have been selected as representative from shipping companies serving the short sea traffics in SW Europe and for the high speed case, a trimaran serving in the Canary Islands. The three ships are an example of each speed group that is the conventional Ro/Pax group represented by ship A, the ship B within the fast Ro/Pax ships and the ship C as the representative of high speed crafts [8].

The cargo capacities of the different selected ships will also be considered, keeping in mind that they are real ships serving short sea shipping traffics (table 3). The calculation is based on their total ship's garage capacity divided by 19.5 meters, obtaining the maximum number of trucks to be carried, showed in table 4 [8].

Particulars	Conventional	Fast conventional	High Speed Craft
Name of ship	Ship A	Ship B	Ship C
Type of ship	Monohull Ro-Ro/pax	Monohull Ro-Ro/pax	Trimaran Ro-Ro/pax
Length	199.14 metres	174 metres	126.7 metres
Breadth	26.6 metres	24 metres	30.4 metres
Draft	6.4 metres	6.42 metres	4.2 metres
DWT	13274 Tm	5717 Tm	1076 Tm
GT	25058 GT	23933 GT	8089 GT
Service speed	18 knots (Max. 24.5)	27 knots	40 knots (30 fully laden)
Cargo capacity	2600 lineal metres	1700 lineal metres	450 lineal metres
Trailers/trucks	157/133	110/97	27/23
Cars	124 lineal metres.	100	123 (341 total)
Passengers	500 Pax	1400 Pax	1291 Pax
Main engines	2 diesel engines	4 Wartsila NSD 12 ZAV 40 S	4 diesel engines
Power	24000 kW	31680 kW	32800 kW
Propulsion	2 Controllable pitch propellers	2 Controllable pitch propellers	3 waterjets
Hull material	Steel	Steel	Aluminium alloy
Year of building	2007	1995	2006

Table 3: Selected ships in the study main particulars. Source own, based on shipping companies information.

The cargo unit is estimated in FEU (very close to a trailer longitude) as it is the common unit of freight in sea and road legs, considering the container filled up to a 60% [9].

Types of ship	Cargo capacity in (FEU)
Conventional ship A	133
Fast conventional ship B	97
High speed craft C	23

Table 4: Cargo capacity depending on each type of ship. Source own.

d) The main engine specific fuel consumption is strongly affected by the installed propulsion systems as engine, gear, shaft or propulsion arrangements; but modern diesel engines have about halved daily fuel consumption compared to the old inefficient steam engines with the same power outtake [10].

The daily ship's fuel consumption, is normally given at full power (85% MCR: Maximum Continuous Rate), assuming therefore that utilized power is 85% of installed power. However the average main engine load and speed varies a lot for different ship types. There is reported by some authors an average load of 80% MCR based on statistical data. For example bulk carriers tend to have slightly lower average values (72% MCR), while tankers have higher (84% MCR). So the load can range from about 60% MCR up to 95% MCR for the analysed ships [11]. The selected engine load has been fixed for our purposes to the 80% of engine load when sailing and 20% for time spent at ports due to auxiliary engines operations. [12]

Type of ship	Speed	Tm/Hour (80%)	Tm/Hour (20%)
Conventional ship	20	3,840	0,960
Fast conventional ship	27	8,068	2,017
High speed craft	40	5,25	1,312

Table 5: Hourly consumption based on the engine load and power. Source own.

e) The emission factors to be considered are taken from the REALISE database. The advantage in CO_2 emission factors in maritime transport could be considered because the lower power needs for a ship to carry the same cargo compared to a truck. However when the ships' speed grows, this advantage can be negligible and even negative. Additionally, the sulphurous emissions are still the weak point for maritime transport, mainly due to the sulphur content of marine fuels. A global average of 2.5% sulphur contents for marine oils is kept in mind, varying however from 0.5% for distillates up to 2.7% for heavy fuel. We must note that high-viscosity heavy fuel tends to have a higher sulphur values compared to lower-viscosity fuels.

At this point the question posed is, it is still viable to propose an ecological bonus for trucks boarding a ship, based on the minor pollutant effect per tonne and kilometre done by a ship in front of a truck?

4. PRELIMINARY RESULTS

Following there is showed the pollutant efficiency performance of the conventional ship, considered as the one generating the lowest level of consumption rate is due to the lowest developed speed, we have previously considered. In the next tables there are showed the figures of external costs saving comparing the cargo capacity of each ship at only the 60% of cargo capacity against the only road one. The resulting figures are showing the external costs savings due to the road distance not carried out.

Potential saving (€) per FEU	Saving (€) per FEU per road km not travelled
310,9277	0,1477
-16,081	-0,0076
-1.542,97	-0,733

Table 6: Total external costs of the unimodal or only sea multimodal, solutions, taking the 200 g/h kW consumption rate for the Ro/Pax ship A, B and C. (Source own, based on pricing costs from REALISE, 2005).

Those external cost savings could be the basis to propose a green bonus to transport companies sending their trucks deciding to embark on a ship with enough cargo capacity to be cleaner than the compared truck doing the same route by shore. It should be noted than when calculating the fastest ships, as cargo capacity decreases, there is a point where the minor cargo capacity, maintaining the engine output, would mean negative savings compared with the same route truck emissions.

Keeping in mind only the scenario where the ship A is compared with road transport, as being the only marine one providing external costs savings, the bonus potentially offered to the truck would be a maximum of 14,7 cents per kilometre not done by the truck, what would motivate a modal shift. However and mentioning different authors like García Menéndez, Martínez and Piñero (2003) or Pérez (2004), they found that the modal shift would be provoked in favour to an increase in the maritime transport share, in the case where a increase of the road transport cost would appear, more than when price would go down in the maritime transport. The crossed elasticity in the maritime transport selection in detriment of the road is around the 1,075%, id est the probability of selecting the maritime transport increases in a 1,075%, for each 1% of road transport cost increase.

From the perspective of a maritime transport improvement in terms of service to the customer or the speeding up of the customs procedures, the calculated elasticity in the previously mentioned studies is evaluated around the 0,641%. What means that a reduction of the freight price to be paid by a truck of 100 € would have only an effect equal to the 64,1% of mode changing intention per each euro reduced, due to a hypothetical environmental bonus offered by the administration, based on the above mentioned method, would be produced.

The intermodal option provides hardly any external cost savings for the five routes because the difference between road and sea distances is sometimes negligible. In addition, road legs in intermodal chains are too long. But increasing oil prices pose a threat to high speed crafts, which are heavily penalized for their high consumption rates, resulting in higher operational costs. In addition, there is concern about their poor environmental performance. The conventional ships are the most environmental friendly ones, being the difference between the fast conventional and high speed crafts bigger than from conventional to fast conventional ships. This slight advantage in conventional ships would be eliminated when considering stricter regulations (Euro VI) for road transport. Mainly if no other measure is taken in the sea side. However keeping in mind specific multimodal transport lines, served by ships with a positive environmental impact in front of the road alternative, the administration could justify some public grants as an economic incentive to convince the user to utilise the maritime transport. One example is the environmental bonus offered by the Italian government in several routes to endorse the trailers and trucks on board a ship instead of doing the route in an only road mode.

In this example, the mentioned administration offered a financial compensation to all shippers carrying their trucks in one of the possibly future 30 motor ways of the sea, identifies in a list. These potential motor ways of the sea would be the itineraries connecting the following Italian ports of Catania, Civitavecchia, Genoa, Livorno, Messina, Naples, Palermo, Salerno and Trapani with Toulon in France or the previous ones with the Spanish o Algeciras, Barcelona, Valencia and Tarragona. Initially the budget offered were around 80 M€ per year during a period of three years. What would mean for the carriers the refund of around the 20 or the 30% of the ship fares, if they do a minimum number of trips.

5. CONCLUSIONS

The intermodal option provides hardly any external cost savings for the five routes because the difference between road and sea distances is sometimes negligible. In addition, road legs in intermodal chains are too long, and increasing oil prices pose a threat to high speed crafts, which are heavily penalized for their high consumption rates, which lead to higher operational costs. Furthermore, there is concern about poor environmental performance. Conventional ships are the most environmentally friendly ones, the difference between fast conventional and high speed crafts being bigger than between conventional and fast conventional ships. This slight advantage of conventional ships would be eliminated if stricter regulations (Euro VI) for road transport were applied, particularly if no other measure is taken for sea transport. However, the better environmental performance of ships serving specific intermodal transport routes could justify the allocation of public grants as an economic incentive to convince users to choose maritime transport. An example is the environmental bonus offered by the Italian government in several routes to endorse trailers and trucks boarding ships instead of covering routes by road only. This action has also been taken by the Basque autonomous government in Spain.

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