

RECORDIT

REAL COST REDUCTION OF DOOR-TO-DOOR
INTERMODAL TRANSPORT

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Deliverable 8: Cost reductions possibilities and options

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Abstract	<p>The objective of this report is to group together the results of previous analytical work packages, and to establish a general overview of intermodal transport costs, compared with the costs of the dominant technology in Western Europe, all-road transport. The comparison first deals with actual present data, and then include reduction assumptions, ensuring a future scenario to be presented. Direct costs and external costs are taken into consideration, thus enabling an assessment of a possible public policy consisting in internalising external costs through an adequate pricing system. The results show that, considering direct costs only, all-road transport has a substantial competitive advantage. If external costs are included, intermodal is slightly cheaper, but the gap is much narrower than usually said and does not even take into consideration such elements as quality of service. An efficient policy, the aim of which would be to support a modal shift from all road solutions to environmental friendly solutions, will have to rely on more enforcement methods than just pricing.</p>
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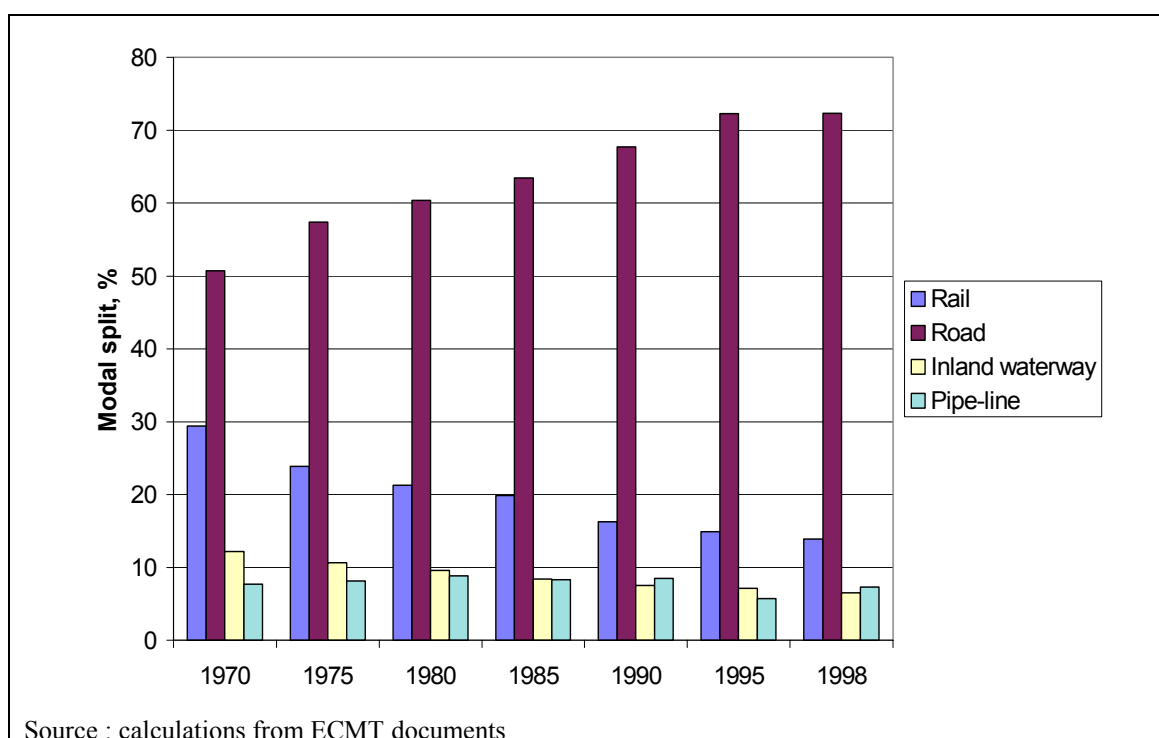
WP 8: Cost reductions possibilities and options

WP 8 consists in exploring cost reduction scenarios, implementing technological, organisational and regulatory changes in intermodal transport chains operation. Its aim is to assess the magnitude of cost reduction one can expect, and therefore to stress the most promising ways to strengthen intermodal transport efficiency and competitiveness, were it through internal costs only (from a market viewpoint) or through global costs, i.e. including external costs (from a socio-economic viewpoint).

One must also consider the way to implement those changes, taking into account the various actors implied in the system and the game, co-operative or not, they can play together considering their respective organisation and advantages.

Simultaneously, one will also consider road transport solutions. As one knows, road is by far the prominent transport mode in Western Europe, the one which sets quality as well as costs standards other technical supply must compete with. Due to many converging factors – better infrastructure network, progress in vehicle technology, search for productivity through bigger, better filled vehicles, intense working process, often exceeding regulatory limits, etc. – road transport is more and more efficient and broadens its market share.

Modal split in Western Europe
Domestic traffic, t.km, European Union + Switzerland and Norway, 1970 – 1998



Considering the strong negative consequences of this general trend, concerning pollution, noise, safety, infrastructure congestion, etc., public authorities at national and at Union level support intermodal transport – then called combined transport – as an alternative to prevailing all-road solutions. It is therefore very useful to compare intermodal and all-road transport costs, distinguishing between direct and external costs, as will be explained. The possible competitive gap between intermodal and road transport will thus be measured, from a private direct cost viewpoint and from a social global cost viewpoint, giving an idea of the amount of efforts a policy should devote to the development of intermodal solutions.

1. METHODOLOGY

Essentially, RECORDIT relies on an analytical study of transport organisation, on the basis of a bottom-up approach. Transport chains are divided into elementary rings, the internal and external costs of which are measured, as often as possible, through a disintegrated observation scheme. The results of these calculations make up all previous WP and provide a substantial basis for WP 8.

The first task of WP 8 therefore consists in particularly exploiting WP 3 and WP 4, dealing with internal and external costs of intermodal and all-road transport along the three representative selected corridors. This is the matter of Chapter 2, "Intermodal corridors present situation", where direct and external are gathered and compared. Chapter 3 gives a "Cost comparison and synthesis", going beyond particular examples and proposing a general assessment of costs prevailing in intermodal and all road transport in Western Europe, insisting on orders of magnitude and on main items, so as to identify cost drivers for future actions and policy making. Chapter 4, finally, explores "Cost reduction perspectives", giving some conclusions and scopes to this step of the project.

• **Exploitation of WP 3, Resource cost calculation for selected corridors**

WP 3 has achieved a resource cost calculation of intermodal and all-road transport along three different corridors. Results differ significantly from one corridor to the other, but enable us to make useful comments and to determine meaningful **cost items**, so as to focus following attention on **cost drivers**, i.e. on the most promising elements of cost, those likely to receive the most important change and improvement towards a better efficiency and competitiveness of combined transport in Europe.

WP3 has divided costs according to a "multi-layer" approach. It starts from the basic transport or handling operations and corresponding actors (road carriers, railway companies, handling companies, who get infrastructure use from a specific entity, but corresponding tolls are not taken into account in the internal cost approach). It then considers a second layer, corresponding to intermodal transport operations. In the case of UIRR (International Road Rail Union), operators provide a yard to yard service, including the provision of a wagon (with corresponding maintenance and depreciation costs). Overhead structure costs and profit margins also must be included in the calculation. UIRR intermodal operators' customers are not shippers but are themselves freight forwarders, among whom some have their own transport means, at least for a part of their needs, and some are only organising and marketing companies. Forwarders therefore represent a third layer in the organisation. They appear as the only spokesperson to the shipper, their price includes all subcontracted operations and their own added value, and comprises the whole door to door service. A fourth and last layer has to be considered, consisting in inside additional costs, necessary to the shipper to manage his own sending and receiving activities. The sum of all these elements enables to calculate the total internal resource cost.

One notices that **infrastructure** costs are not explicitly included into WP 3 direct costs estimate. They are, at least partially, included in the price a carrier charges his shipper-

customer, the carrier himself bearing various taxes related to energy, vehicle possession or usage, etc. This issue is specifically examined in the project (Deliverable 6).

The present layer approach broadly mixes organisational and technical elements. E. g., a road haulage can be undertaken by a basic road carrier, provider to a multimodal operator, or by this latter operator himself. In this chapter, the aim is to measure costs according to a technical split, as later on internal costs will be compared with external costs, obviously estimated according to the same technical split (the pollution of a lorry is the same if it belongs to a simple road carrier or to a sophisticated multimodal operator). Internal resource costs will therefore be consolidated according to basic technical operations, making a systematic distinction among transport modes, the environmental performances of which are very unequal and underlie the European common transport policy, in favour of a different modal split.

• **Exploitation of WP 4, External costs calculation for selected corridors**

The calculation of external costs is completely different from resource cost calculation, given external costs are not, by definition, not determined by a market and therefore require another approach. The methodology of external cost calculation is the purpose of abundant and ongoing scientific discussion, presented in previous WP 2 and in WP 4 itself. We shall not take these elements into consideration again, but just examine quantitative results they have produced.

These results are presented according to a double classification. On the one hand, they cover a wide range of external effects, consisting in : nuisances of electricity production, air pollution, noise, accidents, congestion, global warming, and also external cost linked to manufacture and maintenance of equipment and process. On the other hand, they are calculated for each homogeneous corridor segment and type of operation. These operations are, of course, the same as the ones considered in resource cost calculation (WP 3) : rail, short sea shipping, inland waterway, road (for all-road solutions as well as for pre and post-haulage in intermodal chains) and transshipment. Organisation and marketing operations are immaterial and obviously do not have external costs.

The reduction of intermodal transport does not only deal with operational resource costs. Reduction of external costs is another important issue. Here again, the identification of heaviest items will produce cost drivers, and help to point out where priority efforts have to be made.

The very order of magnitude of some external costs is somewhat surprising, which is an interesting contribution to scientific and political debates about freight transport. Road nuisances are well known, and their quantification just adds to their knowledge and consideration. But alleged "clean" transport modes are not as environment friendly as one might think, and should make some progress to really contribute to a new policy.

• **Synthesis**

Being calculated according to the same analytic method, resource and external costs will finally be compared and added, as a result of the core of RECORDIT project research process. A partial bias was not entirely avoided: double accounting of some external costs, given they are explicitly assessed in D4, but are already partially

included in direct costs, as they are assessed in D3 (through taxes and accises, which are included in transport service prices and therefore already contribute to the internalisation of external costs).

The proportions of resource and external costs is a major concern : how do market prices reflect socio-economic mechanisms, what change can one expect from a possible "re-internalisation" of external effects ? In particular, would such a change substantially modify the competitiveness of different all-road and intermodal transport solutions ? This is of course a fundamental issue,

2. INTERMODAL CORRIDORS PRESENT SITUATION

2.1. Trimodal chain on the corridor between Genova, Basel, Rotterdam and Manchester

WP 3 has established a cost calculation according to different cases and, in the Genova-Manchester case, has assessed costs for a 20' container (TEU) and for a 40' container (FEU). In the following step of present WP 8, internal costs will be compared with external costs (calculated in WP 4). It happens that external have been calculated for a TEU only. Therefore, the comparison and sum of internal and external costs will be also done for a TEU only.

Indeed, a conversion of costs from a TEU to a FEU is theoretically possible, considering haulage costs depend on the size of a shipment (and that a TEU bears half the cost of a FEU) whereas costs are the same for transshipment operations. But a certain uncertainty would remain, regarding structural, marketing or organisational costs (are they proportional to primary costs, or are they linked to the number of operations, and therefore are about the same for a TEU and a FEU, whatever their cost and price levels?).

2.1.1. Direct costs

Cost analysis in WP 3 has produced following figures, that will be gathered and aggregated in the following tables and charts and be the subject of various comments.

- **Intermodal corridor**

**Intermodal transport direct cost
Genova – Manchester, € / TEU**

Rail	
Genova-Basel	258
Felixstowe-Manchester	40
Total rail	298

Inland waterway	
Basel-Rotterdam	154

SSS	
Rotterdam-Felixstowe	220

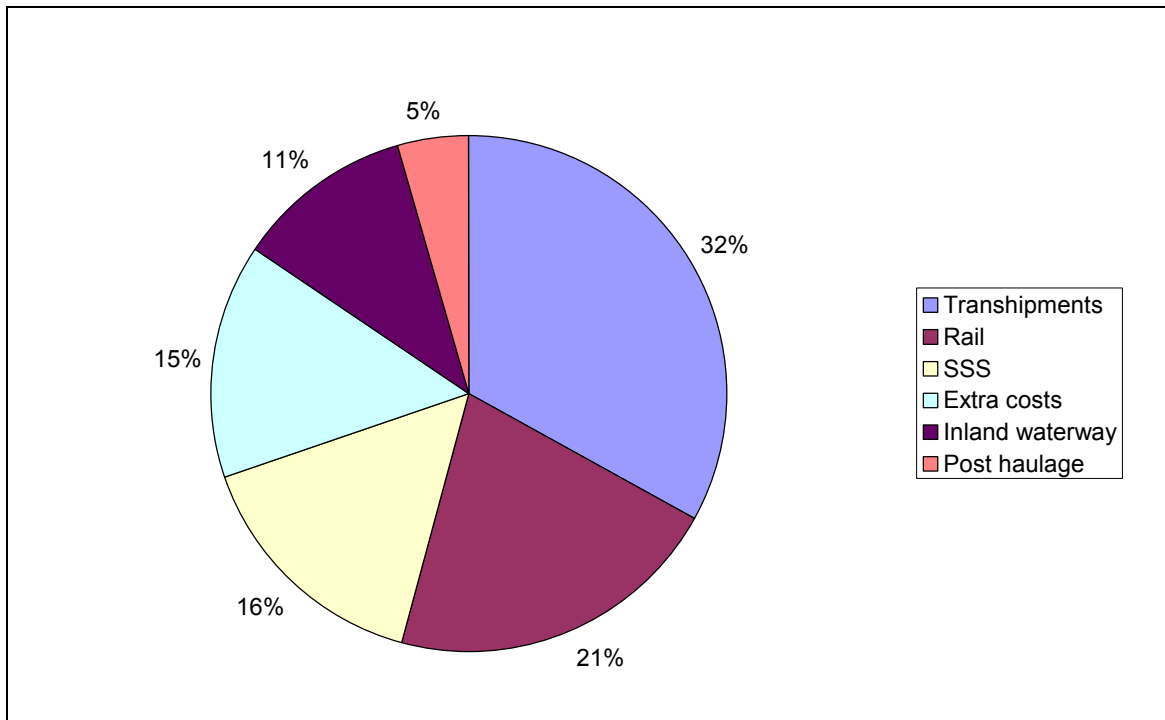
Transshipments	
Voltri Terminal (Genova)	88
Basel	31
Basel	50
Klienhüningen	50
Rotterdam	174
Felixstowe	40
Trafford	30
Total transhipments	463

Road posthaulage	
Road Basel	7
Trafford-Preston	57
Total road haulage	64

Extra costs	
MTO	30
Shipping agent	20
MTO	-20
Forwarding	158
Shipper consignee	18
Total extra costs	206

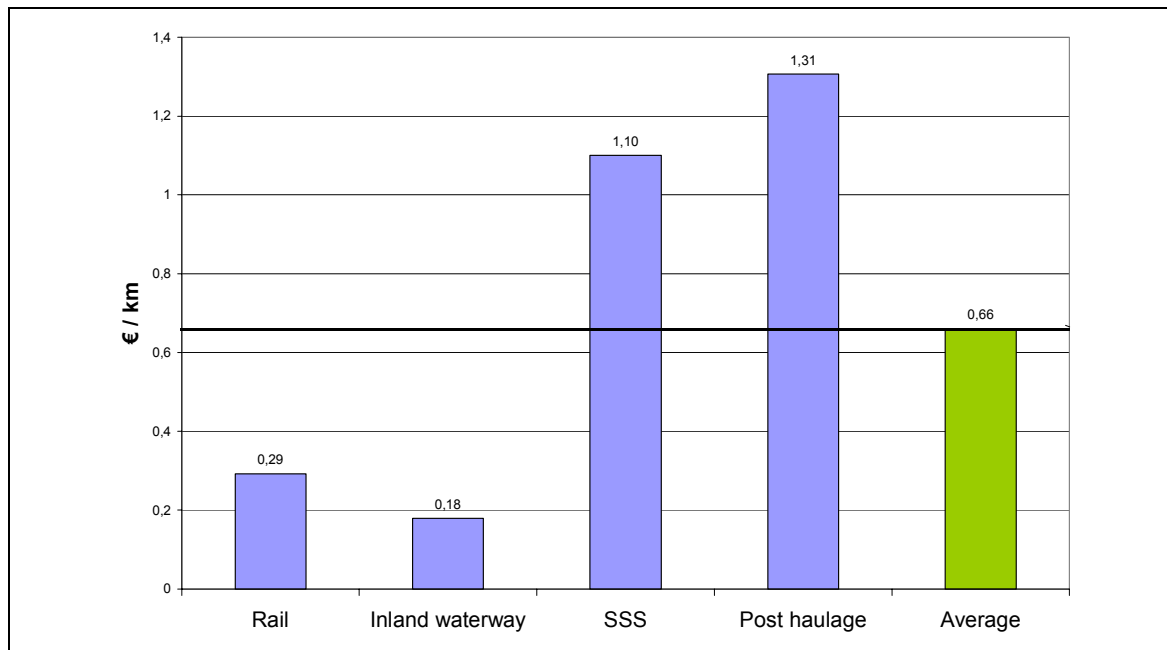
Total	1405
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**Intermodal transport direct cost structure
Genova - Manchester**



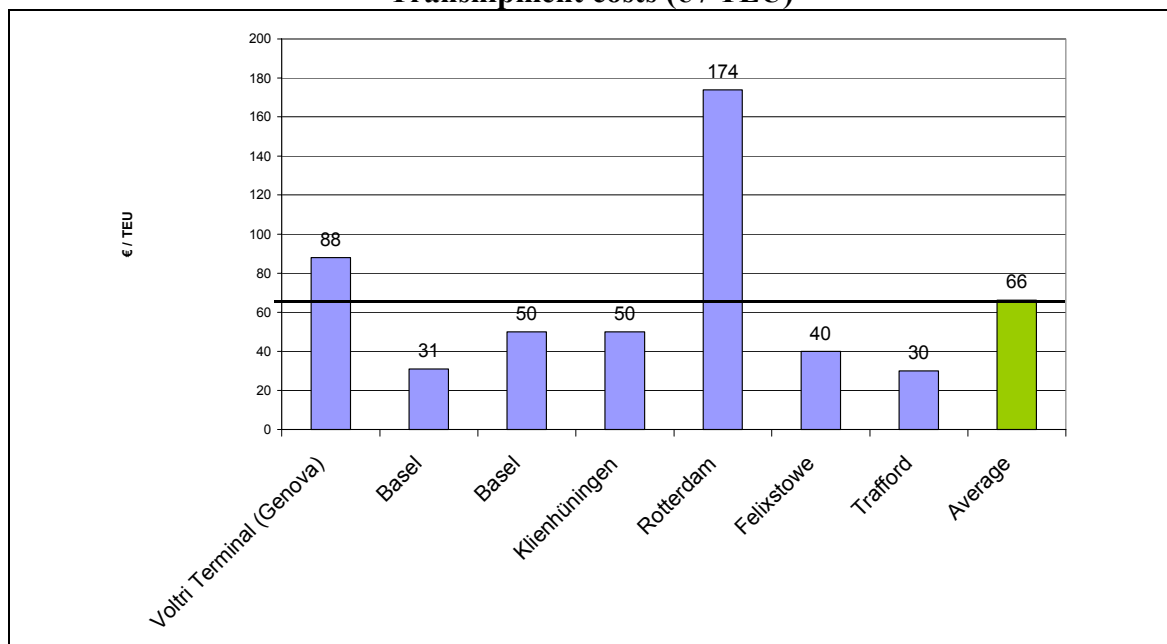
The structure of total cost has to be analysed. Long distance haulage only represents less than half of the global cost (48 %) whereas short distance haulage and transhipments represent 38 % and extra costs 15 %. Transhipments are the heaviest item of the list! If one wants to diminish total cost, efforts do not have to focus on long distance haulage only. Local operations weigh nearly as much and often represent a more important "progress deposit", considering little effort has yet been given to their improvement. Transhipment in Rotterdam seems particularly costly, as its amount is more than four times higher than the one in Felixstowe.

Intermodal transport direct distance costs, Genova – Manchester



Proper transport operations (separately from local handling operations, transhipments and other extra costs) correspond to particular segments, i. e. to particular distances. Average cost per kilometre can therefore be calculated. Some results of this calculation are not surprising: inland waterway is the cheapest means, and rail is cheaper than road. But some others are unexpected and deserve to be emphasised. Road post haulage is of course quite costly, considering the important of fixed costs (waiting time for driver and vehicle), with an average cost seven times higher than the one of inland waterway. But short sea shipping appears as surprisingly expensive, all the more so as transhipment costs have to be added to mere transport. This item represents 16 % of total cost for 9 % of total distance.

Transhipment costs (€ / TEU)



When one adds short sea shipping from Rotterdam to Felixstowe and corresponding transshipments on both ends, the total amount, 458 €, represents 32 % of the door to door cost! One would expect a better efficiency from a massive, aggregated means of transport. This situation, if it were representative of short sea shipping possibilities in Europe, would be quite worrying, considering hopes linked with the development of this technology, to alleviate inland transport congestion in years to come.

- **All-road corridor**

All-road solution is, properly speaking, impossible along the Genova-Manchester corridor, given the Channel must be crossed either by sea or by train (through the tunnel). Sea solution has here been chosen, so as to keep close to the studied intermodal solution.

The total door-to-door cost, as borne by the shipper, has been estimated at a 1216 € level (for a TEU loading unit), comprising 264 € for the maritime segment from Rotterdam to Felixstowe. As it is, this cost is lower than the one of the intermodal solution, estimated as 1405 € for the same load.

2.1.2. External costs

- **Intermodal corridor**

The calculated amount of external costs along the Genova-Manchester corridor is summed up in the following table. The total cost is about 150 €, which can be divided into nuisances sources or into transport modes.

**Intermodal transport external cost
Genova – Manchester, € / TEU**

€/TEU	Electricity	Air pollut.	Noise	Accid.	Congestion	Global warming	Process	Total
Rail	4,1	0	4,4	10,9	0	3,3	1,4	24,1
Inland waterw.	0	23,5	0	0	0	9,1	1,1	33,7
SSS	0	12,8	0	0	0	1,6	0	14,4
Transshipments	0,3	0,0	0,0	0,0	0,0	0,3	0,0	0,7
Post haulage	0	2,6	2,3	3,9	0	2,2	1,5	12,5
Total	4,4	38,9	6,7	14,8	0,0	16,5	4,0	85,4

An easier way to comment these data is to consider percentages, as in the following table.

**Intermodal transport external cost structure
Genova – Manchester, %**

%	Electri- city	Air pollut.	Noise	Accid.	Congestio n	Global warming	Process	Total
Rail	4,8	0,0	5,2	12,8	0,0	3,9	1,6	28,2
Inland waterw.	0,0	27,5	0,0	0,0	0,0	10,7	1,3	39,5
SSS	0,0	15,0	0,0	0,0	0,0	1,9	0,0	16,9
Tranship ments	0,4	0,0	0,0	0,0	0,0	0,4	0,0	0,8
Post haulage	0,0	3,0	2,7	4,6	0,0	2,6	1,8	14,6
Total	5,2	45,6	7,8	17,3	0,0	19,4	4,7	100,0

Among transport modes, inland waterway is first in external costs, with nearly 40 % of the total door-to-door corridor. Its main drawback is air pollution, representing more than 27 % of total external cost. Rail also matters, with over 28 % of total external cost. Short sea shipping contributes for 17 % of costs although is used on a short distance only, and final road haulage for 15 %, whereas transshipments are nearly negligible.

Among nuisance sources, air pollution comes first (46 % of total cost), followed with global warming (19 %).

When one crosses both criteria (5 modes and 7 sources of nuisance), 5 items out of 35 explain more than 80 % of total external cost : rail noise (43 %), inland waterway air pollution (16 %), short sea shipping air pollution (9 %), rail accidents (7 %) and inland waterway global warming (6 %). These are cost drivers, which can receive specific solutions and show substantial improvements.

• **All-road corridor**

All-road transport (including short sea shipping segment) is, as expected, more costly than intermodal transport, considering external effect. But the absolute difference is not very big, as all-road is estimated at a 236 € cost for a TEU transport, compared with 150 € for intermodal solution.

**All-road external cost
Genova – Manchester, € / TEU**

€ / TEU	Electri- city	Air pollut.	Noise	Accid.	Congestio n	Global warming	Process	Total
Road	0	46,9	9,5	66,2	11,2	47,4	28,4	209,6
SSS		12,8				1,6		14,4
Total	0	59,7	9,5	66,2	11,2	49	28,4	224

The split of external costs for the (so-called) all-road solution, in percentages, is as following.

**All-road external cost structure
Genova – Manchester, %**

%	Electri- city	Air pollut.	Noise	Accid.	Congestio n	Global warming	Process	Total
Road	0	20,9	4,2	29,6	5,0	21,2	12,7	93,6
SSS	0	5,7	0,0	0,0	0,0	0,7	0,0	6,4
Total	0	26,7	4,2	29,6	5,0	21,9	12,7	100,0

Out of 14 items, 3 represent more than 72 % of total external cost : road accidents (30 %), road air pollution (21 %) and road global warming (21 %).

2.1.3. Total cost

In the preceding analysis of external cost, a distinction was made between various cost sources, and a comment was given on key figures, i.e. cost drivers on which improvement efforts should focus. In the present paragraph, one will only consider costs (direct as well as external) divided between modes, as the key issue is now compared competitiveness among studied solutions.

• Intermodal corridor

The sum of direct resource costs and of external costs is as following. In the fifth column of the table, the percentage of external cost, considering total cost, is calculated. External costs do not represent a very high proportion of total cost (9 % as an average) : using rail or inland waterway on as long distances as possible, intermodal solutions generate less nuisances than all-road solutions.

But external costs show a great unevenness according to different components of intermodal transport chain. They represent up to 22 % of total rail cost, 19 % of inland waterway total cost, whereas both these modes are usually considered as non-pollutant. Even road haulage (with a 10 % index) does not bear such an additional socio-economic charge.

**Intermodal transport total cost
Genova – Manchester, € / TEU**

€ / TEU	Direct costs	External costs	Total	% Ext. cost / total
Rail	298	24,1	322	7,5
Inland waterway	154	33,7	188	18,0
SSS	220	14,4	234	6,1
Transhipments	463	0,7	464	0,1
Post haulage	64	12,5	77	16,3
Extra costs	206	0	206	0
Total	1405	85	1490	5,7

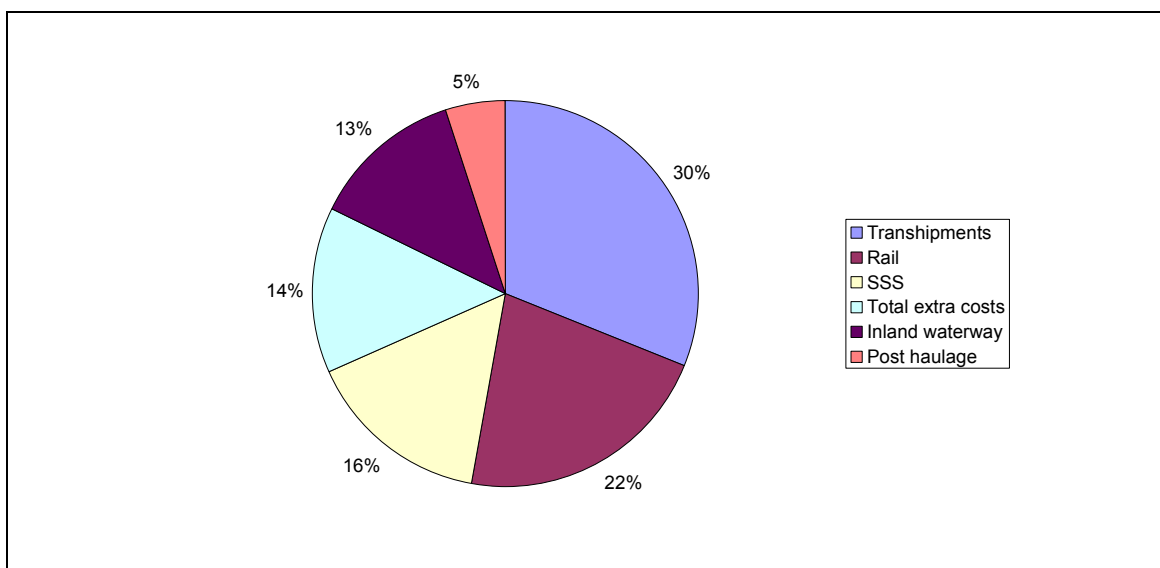
A calculation in percentages will make further comments easier.

**Intermodal transport total cost structure
Genova – Manchester, %**

%	Direct costs	External costs	Total
Rail	20,0	1,6	21,6
Inland waterway	10,3	2,3	12,6
SSS	14,8	1,0	15,7
Transhipments	31,1	0,0	31,1
Post haulage	4,3	0,8	5,1
Extra costs	13,8	0,0	13,8
Total	94,3	5,7	100,0

The hierarchy of cost items is not fundamentally altered, compared with direct costs. Transhipments are still the biggest cost (31 % of total cost), followed by rail (22 %), by short sea shipping (16 %), extra costs (14 %) and inland waterway (13 %). Given the total cost is shared between several components in nearly equal proportions, efforts to lessen cost cannot focus on a few items but must touch all of them. Still, a reduction in transhipment costs, which is primarily an organisational issue, seems to be a priority.

**Intermodal transport total cost structure
Genova – Manchester, %**



• **All-road corridor**

Adding up data provided by WP 3 and WP 4 lead to a total cost calculation for the so-called all-road solution, comprising a short sea shipping segment.

**All-road transport total cost
Genova – Manchester, € / TEU**

€ / TEU	Direct costs	External costs	Total	% Ext. Cost / total
Road	952	210	1162	18,1
SSS	264	14	278	5,2
Total	1216	224	1440	15,6

The percentage of external cost, considering total cost, is higher than for intermodal transport, but in a rather limited proportion : the average is 16 % (compared with 6 %), and affects mainly road haulage (18 %) and not maritime haulage (5 %).

Considering global percentages, one can say that cost reduction efforts should touch direct costs, for road (66 % of total cost) and short sea shipping (18 %).

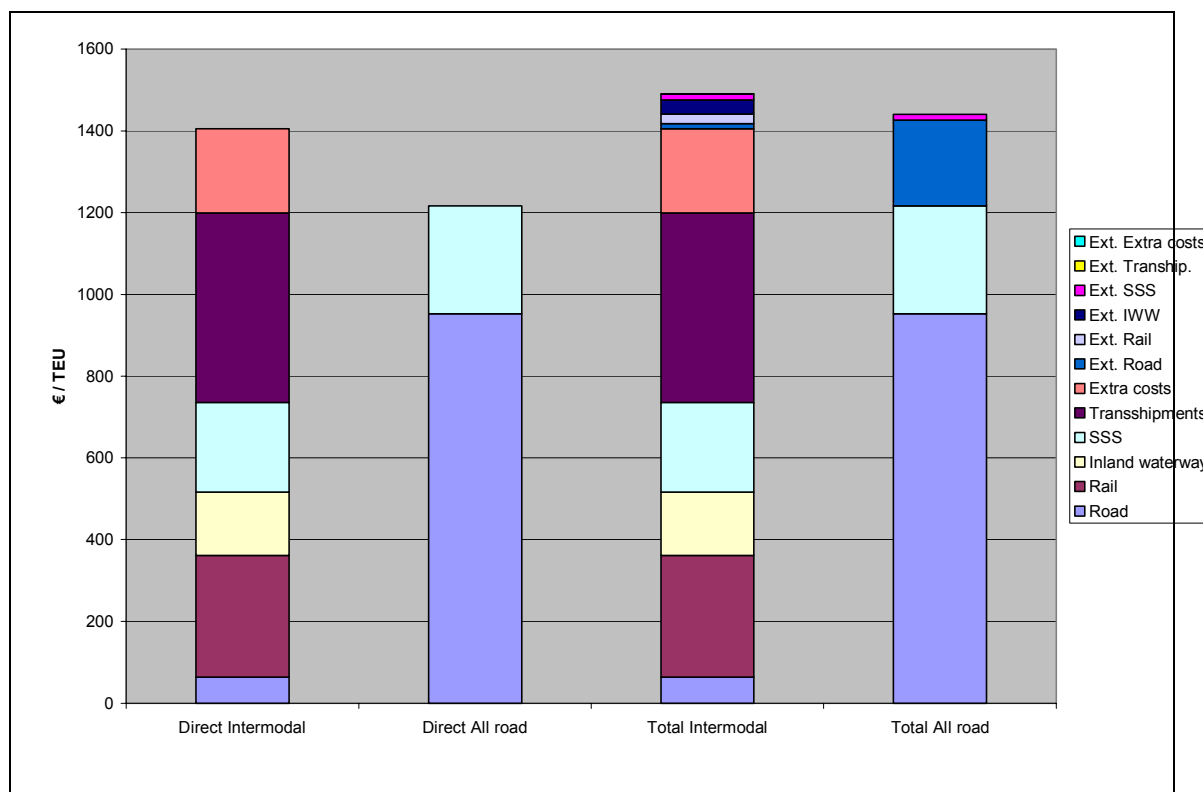
**All-road transport total cost structure
Genova – Manchester, %**

%	Direct costs	External costs	Total
Road	65,6	15,3	80,8
SSS	18,2	1,0	19,2
Total	83,8	16,2	100

• **Comparison**

It is now possible to compare total costs for both solutions, concerning direct costs (reflected in market prices) and total costs (including external socio-economic costs). Comparisons rely, as previously, on calculations in € and concerns a TEU container, from Genova to Manchester.

**Direct and total costs, intermodal and all-road corridors
Genova-Manchester, € / TEU**



The door-to-door direct cost from Genova to Manchester through the intermodal chain is 1405 € for a TEU container, and only 1216 € by road. If one takes external costs into account, total prices are respectively 1490 € and 1440 €. As the chart shows, the competitiveness of both solutions is slightly altered, under the assumption that external costs are internalised, but no major change occurs. All-road is cheaper than intermodal transport under price comparison : it shows a 13 % direct cost advantage, not taking into account other advantages such as reliability, flexibility, lead-time, etc. If one considers global costs, road advantage is smaller, but remains in its favour (it diminishes to a 3 % rate).

The main political conclusion of this comparison is that, assuming it would be technically and politically feasible, **internalisation of external costs would not be enough to modify freight modal split on the Genova-Manchester corridor !** Competitiveness of intermodal solutions should benefit from efforts in cost reductions (mainly direct and secondarily external costs, as percentages have shown). But the main outcome of this analysis is that, if political responsible want to modify modal split, they will have to go even further than external costs internalisation (can one think of an even higher level of taxes burdening road transport ?) or will have to rely on other means than on price mechanisms : modal compulsory assignment, traffic quotas, licences, etc. These means are not out of reach, as they have till recently or are still used in European countries supporting a particularly determined transport policy : Austria and Switzerland, dealing with Alps transit regulation.

2.2. Intermodal corridor between Athens, Patras, Brindisi, Milan, Munich, Hamburg and Gothenburg

In WP 3 as well as in WP 4, calculations of direct resource costs and of external costs have been achieved, considering the same LU (Loading Unit) : a class A, i.e. 13 meter long, swap body. All following calculations and comments will deal with the same unit.

2.2.1. Direct costs

A systematic technological description of intermodal chain from Athens to Gothenburg is given in WP 3 and WP4. Various segments belong to different transport modes (rail as the longest haulage means, but also road for pre and post-haulage and ferry from Greece to Italy), without leaving out transshipments and, apart from physical operations, extra costs related to forwarding activities and other shipper's expenses.

• Intermodal corridor

In the following table, costs are grouped in consideration of modes, given external costs that will be analysed later on are established on the same basis.

Intermodal transport direct cost Athens-Gothenburg, € / SB A

Pre and post haulage	
Athens-Patras	220
Brindisi-Brindisi	31
Gothenburg	125
Total	376

Ferry (SSS)	
Patras-Brindisi	266

Rail	
Brindisi-Milano Sm.	483
Milano-Munchen	227
Munchen-Hamburg	439
Hamburg-Gothenburg	606
Total rail	1755

Transshipments	
Patras	27
Brindisi	21
Brindisi	36
Milano Sm.	15
Munchen	18

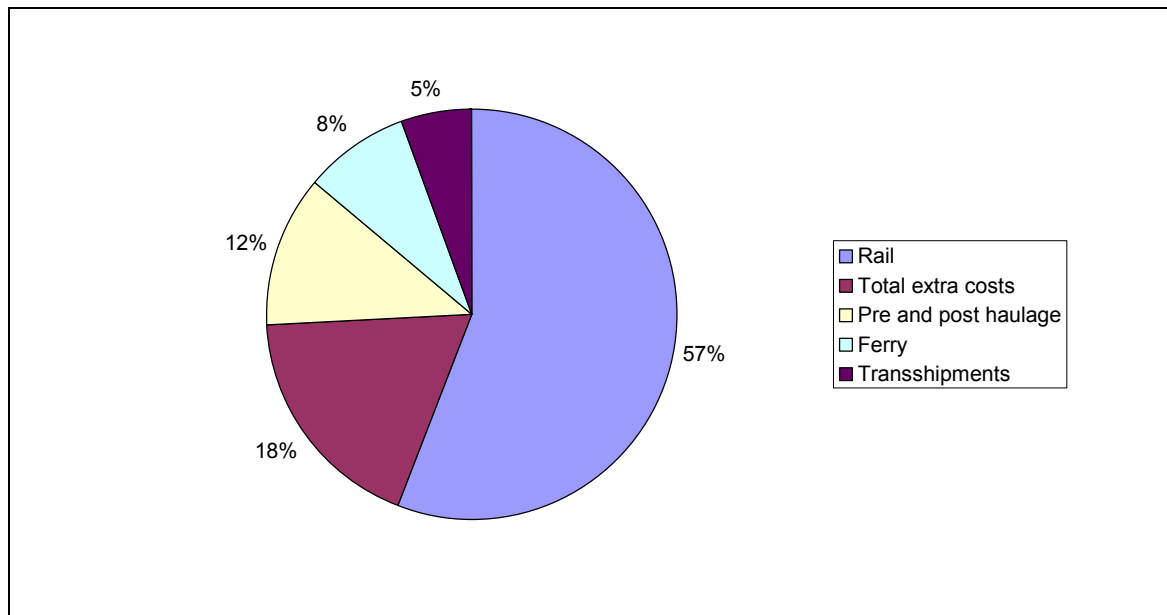
Hamburg	21
Gothenburg	33
Total trans.	171

Extra costs	
MTO	104
MTO	52
MTO	-57
Forwarding	371
Shipper consignee costs	22
Toll	58
Toll	14
MTO	7
Total extra costs	571

Total intermodal	3139
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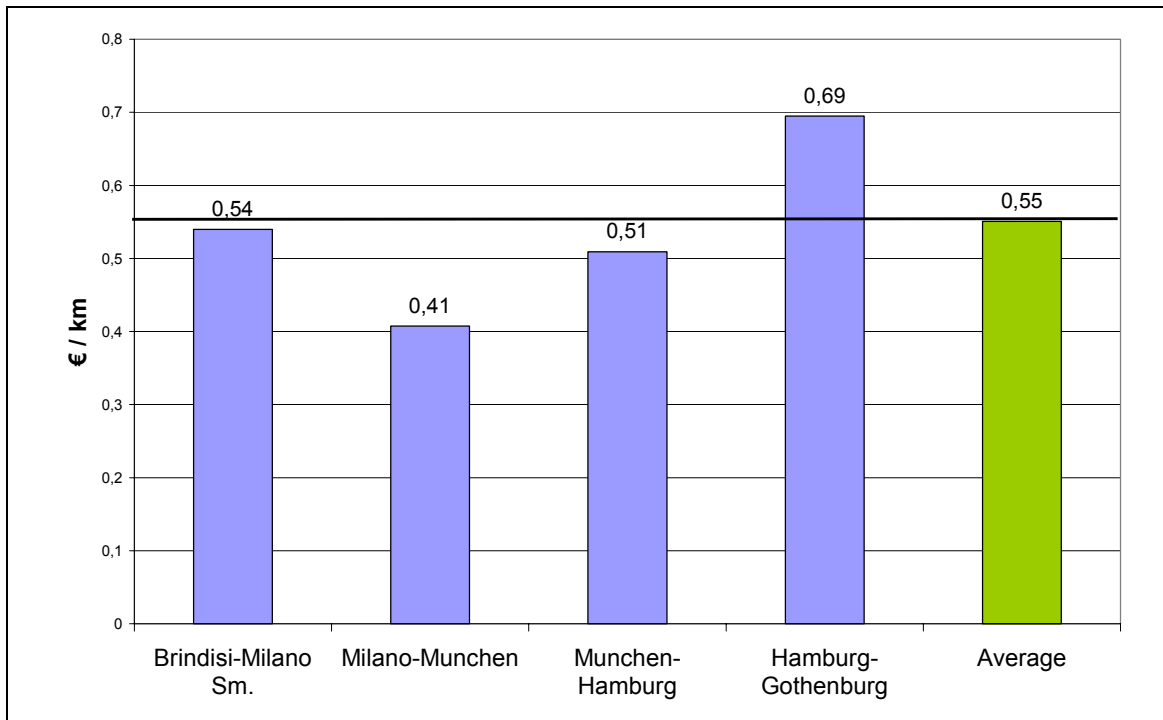
Total door-to-door cost is calculated as 3139 € for a Class A swap body from Athens to Gothenburg. Rail represents the heaviest component of this sum, but an easier way to consider the proportions of various cost items is to establish its structure, in percentage.

**Intermodal transport direct cost structure
Athens-Gothenburg, SB A, %**



Rail cost per kilometre does not show a particular unevenness, as shown by the following chart. Milano-Munich still is quite below the average, whereas Hamburg-Gothenburg is clearly over.

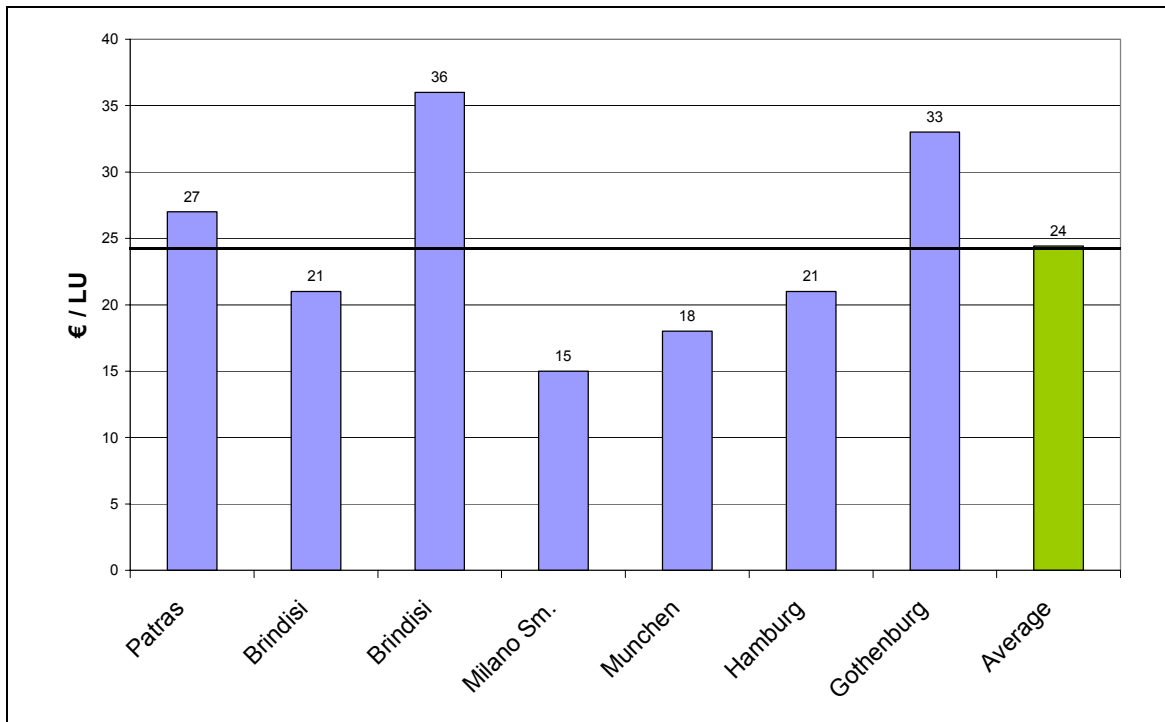
Rail distance cost (€ / km)
Athens-Gothenburg



Rail weighs over half of total cost (57 %), while among other items the main contributions are extra costs (organisation and marketing activities of forwarder, multimodal transport operator, shipper, etc. : 18 %) and road pre and post haulage (12 %). The maritime segment (Patras-Brindisi) does not seem so expensive as the Rotterdam-Felixstowe one in the Genova-Manchester case, and transhipments also represent but a limited share of total cost (5 %).

Transshipment cost differ from place to place but, even if Brindisi and Gothenburg are more expensive, whereas Milan and Munich are cheaper than the average, differences are not very large.

**Transshipment cost
Athens-Gothenburg, € / LU**



• **All-road corridor**

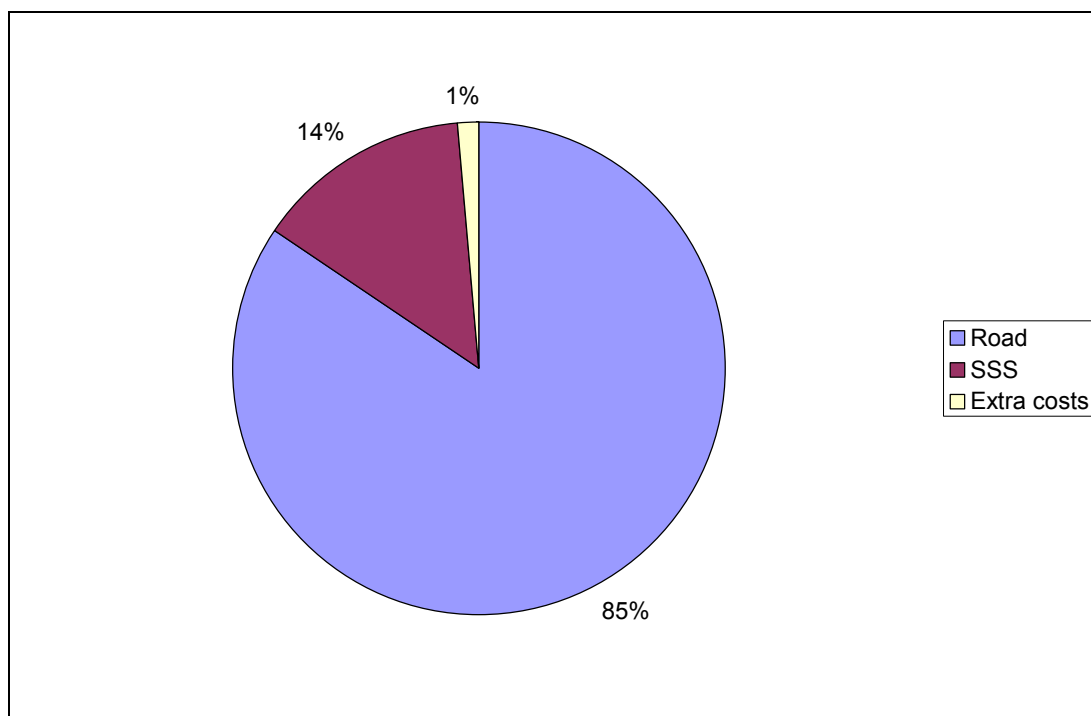
**All-road transport direct cost
Athens-Gothenburg, € / SB A**

Road only	2187
Pre and post haulage	345
SSS	418
Extracosts shipper	44
Total	2994

Compared with intermodal chain, all-road solution is somewhat cheaper (with a 2994 € for a Class A swap body, compared with 3139 €), but the difference is not very important.

Not surprisingly, road is the main component of this sum, all the more so if one considers that pre and post haulage can be included, together with long distance haulage, into a single road cost item. The following percentage chart makes this observation clear.

**All-road transport direct cost structure
Athens-Gothenburg, SB A, %**



2.2.2. External costs

• Intermodal corridor

The calculated amount of external costs along the Athens-Gothenburg corridor is summed up in the following table. The total cost is about 690 €, which can be divided into nuisances sources or into transport modes and transhipments.

**Intermodal transport external cost
Athens-Gothenburg, € / SB A**

€/ SB A	Electri- city	Air pollut.	Noise	Accid.	Conges- tion	Global warming	Process	Total
Pre haulage	0	22	25	49	0	20	15	132
Ferry	0	163	0	0	0	82	49	293
Rail	25	0	26	52	0	50	8	160
Transh.	1	0	0	0	0	1	0	1
Total	26	185	51	101	0	153	72	586

The structure of these external costs is as follows.

Intermodal transport external cost structure
Athens-Gothenburg, SB A, %

%	Electri- city	Air pollut.	Noise	Accid.	Conges- tion	Global warming	Process	Total
Pre haulage	0	3,8	4,2	8,4	0	3,4	2,6	22,4
Ferry	0	27,8	0	0	0	13,9	8,3	50,0
Rail	4,3	0	4,4	8,8	0	8,6	1,4	27,4
Transh.	0,1	0	0	0	0	0,1	0	0,2
Total	4,4	31,5	8,6	17,2	0	26,0	12,3	100

Among 28 items, a few represent a high percentage of total external cost. Rail is an environmental friendly mode, as it causes 27 % of external cost, whereas it provides transport on the longest distance in the chain. The most disappointing mode, from this point of view, is undoubtedly maritime transport, in spite of the relatively short distance it represents in proportion of the whole origin-destination span: air pollution is 28 % of total cost, global warming 14 % and process 8 %. Altogether, these 3 items represent 50 % of external cost.

• **All-road corridor**

All-road transport external cost (including short sea shipping segment) is calculated as follows. It appears substantially more costly than for intermodal transport : 1122 € instead of 586 €. One of the questions this observation asks is whether this gap is sufficient, in the case of a possible internalisation, to modify the terms of competitiveness among various modal solutions. This will be examined later on.

All-road external cost
Athens-Gothenburg, € / SB A

€/ SB A	Electri- city	Air pollut.	Noise	Accid.	Congestio n	Global warming	Process	Total
Road	0	126	37	403	15	157	91	828
SSS		163	0	0	0	82	49	293
Total	0	289	37	403	15	239	139	1122

Proportions will help showing cost drivers.

**All-road external cost structure
Athens-Gothenburg, SB A, %**

%	Electri- city	Air pollut.	Noise	Accid.	Conges- tion	Global warming	Process	Total
Road	0	11,2	3,3	36,0	1,3	14,0	8,1	73,9
SSS	0	14,5	0	0	0	7,3	4,3	26,1
Total	0	25,7	3,3	36,0	1,3	21,3	12,4	100

Road accidents represent the heaviest item (36 %) of total external cost. But air pollution (11 % due to road and 15 % due to short sea shipping) and global warming (14 % due to road) cannot be neglected. Altogether, these 4 components represent 75 % of the whole external cost of so-called all-road solution from Athens to Gothenburg.

2.2.3. Total cost

It is now likely to consider total cost, including both direct resource cost and external cost, for intermodal and for all-road solutions, and then to compare them under these various criterion.

- **Intermodal corridor**

**Intermodal transport total cost
Athens-Gothenburg, € / SB A**

€ / SB A	Direct cost	External cost	Total	% External cost
Pre and post haulage	376	132	508	26
Ferry	266	293	559	52
Rail	1755	160	1915	8
Transshipments	171	1	172	1
Total extra costs	571		571	0
Total	3139	586	3725	16

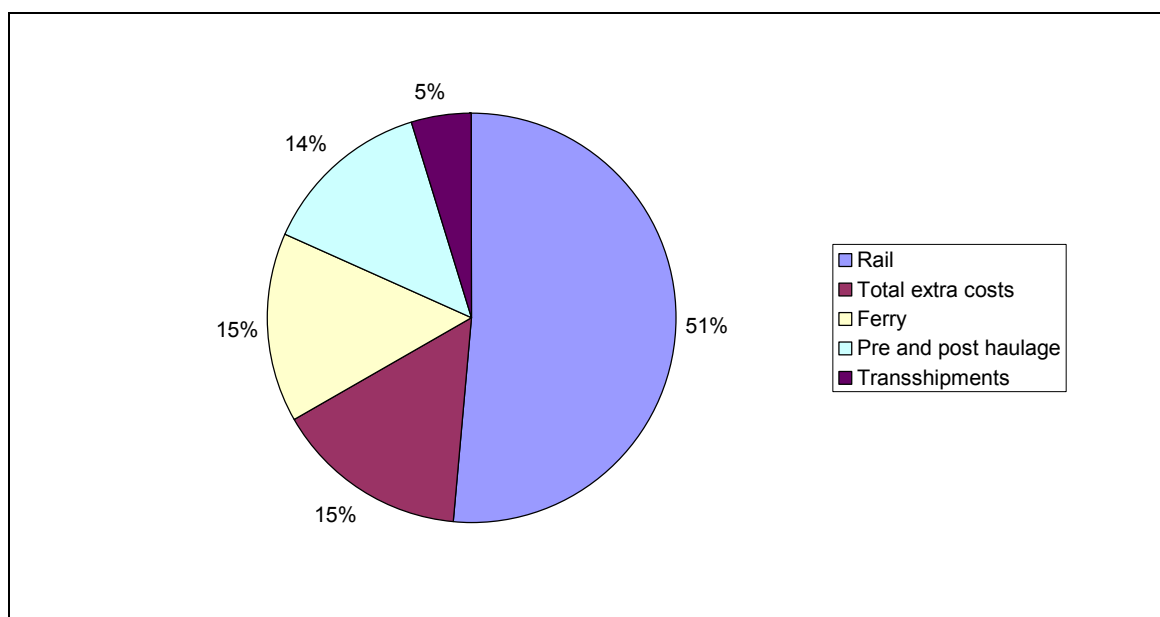
When one adds external cost to direct cost, the door-to-door intermodal transport from Athens to Gothenburg skips from 3139 € for a Class A swap body to 3725 €, external cost representing an average of 16 % of total cost. In fact, external cost shows a very uneven ratio, from one segment of the chain to the other, as percentages show.

**Intermodal transport total cost structure
Athens-Gothenburg, SB A,%**

%	Direct cost	External cost	Total
Pre and post haulage	10,1	3,5	13,6
Ferry	7,1	7,9	15,0
Rail	47,1	4,3	51,4
Transshipments	4,6	0,0	4,6
Total extra costs	15,3	0,0	15,3
Total	84,3	15,7	100

The main items in the total cost correspond to rail haulage (46 %) and to extra costs (15 %). Every effort on these sums, be it technological or organisational, will help strengthen intermodal transport competitiveness. But a substantial progress can certainly be made, dealing with external cost of maritime transport (8 % of total cost) and of course with road pre and post haulage, which is always expensive considering the short distance it serves (road haulage is about three times more costly, compared with rail or shipping, per kilometre). In comparison with others, transshipments along this corridor seem not to be too costly.

**Intermodal transport total cost structure
Athens-Gothenburg, SB A,%**



• All-road corridor

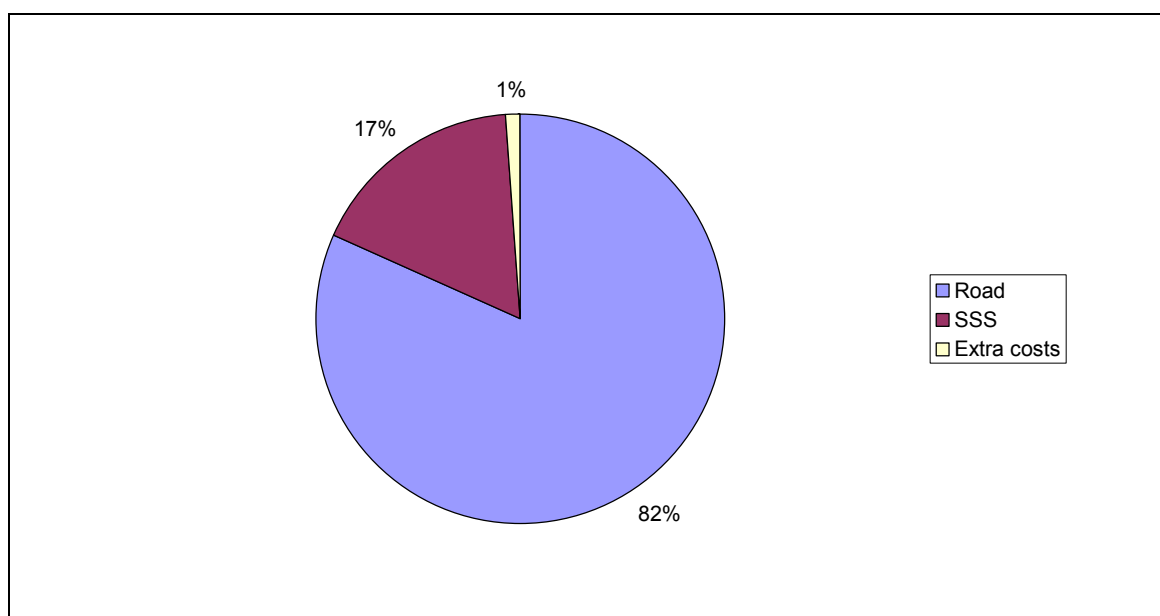
For all-road solutions (including a short sea shipping segment from Greece to Italy), external costs show a rather high level, compared to direct cost, and raises up to 27 % of the total cost.

**All-road transport total cost
Athens-Gothenburg, € / SB A**

€ / SB A	Direct costs	External costs	Total	% Ext. / total
Road	2532	828	3360	24,6
SSS	418	293	711	41,2
Extra costs	44		44	0,0
Total	2994	1121	4115	27,2

Once again, one notices the high amount of short sea shipping nuisances (42 % of total shipping cost), but the main cost remains road, internal or external.

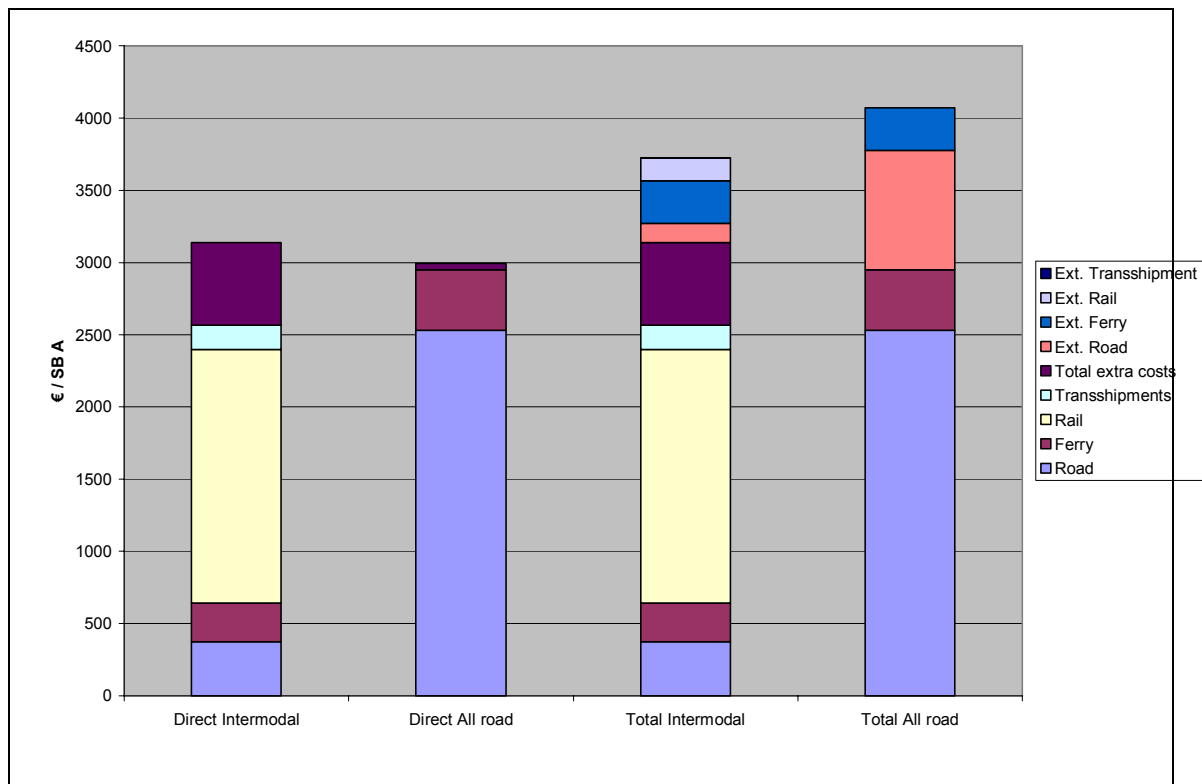
**All-road transport total cost structure
Athens-Gothenburg, SB A,%**



• **COMPARISON**

Due to the high proportion of external cost in total cost on the Athens-Gothenburg corridor, the comparison of intermodal and all-road transport organisation, according to the inclusion or exclusion of external cost (16 % of total cost for intermodal transport, 27 % for all-road transport), is particularly interesting.

Direct and total costs, intermodal and all-road corridors Athens-Gothenburg, € / SB A



Indeed, although absolute differences are not very important, one must note a conspicuous element. Road is cheaper than intermodal transport when only direct resource cost is taken into account: with 2994 € instead of 3139 € for a Class A swap body, road shows a 5 % advantage. But, on the contrary, intermodal transport (3725 €) is cheaper than all-road (4071 €) if the comparison also covers socio-economic costs, with a 5 % advantage.

In this case, internalisation of external cost could give some competitiveness to intermodal chain, vis a vis all-road haulage. But the difference in favour of intermodal solutions would remain marginal, and not likely to compensate qualitative drawbacks dealing with lead-time, reliability, flexibility, tracking of the consignment, etc. Efforts to reduce direct and external costs are certainly necessary.

2.3. Intermodal corridor between Barcelona and Warsaw

As in the former corridor, calculations of direct resource costs and of external costs in WP 3 and WP 4 have been achieved, considering the same LU (Loading Unit) : a class A, i.e. 13 meter long, swap body. All following calculations and comments will deal with the same unit.

2.3.1. Direct costs

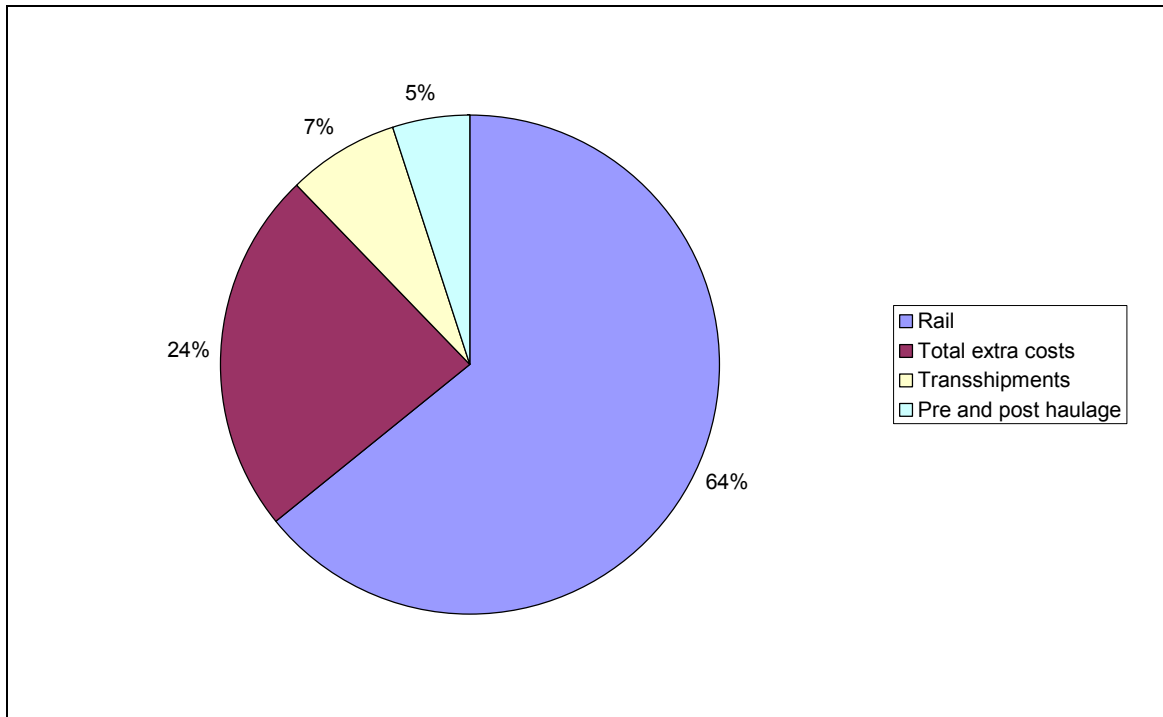
• Intermodal corridor

Various components of cost are calculated as follows.

Intermodal transport direct cost Barcelona-Warsaw, € / SB A	
Pre and post haulage	
Barcelona	60
Warsaw	117
Total	177
Rail	
€/ SB A	
Barcelona-Port Bou	69
Port Bou-Lyon	180
Lyon-Modane	106
Modane-Torino	58
Torino-Bologna	289
Bologna-Verona	174
Verona-Villa	230
Villa-S. Sredisce	199
Sredisce-Kotoriba	39
Murakeresztur-Budapest	214
Budapest-Hidasnemeti	193
Hidasnemeti-Muszyna	176
Muszyna-Warsaw	296
Total	2223
Transshipments	
€/ SB A	
Barcelona	27
Port Bou	28
Lyon	28
Torino	36
Bologna	41
Verona	14
Budapest	17
Budapest	17
Warsaw	34
Total	242
Extra costs	
MTO	119
MTO	291
MTO	32
MTO	-55
Forwarder	405
Shipper	25
Total	817
Total intermodal	3459

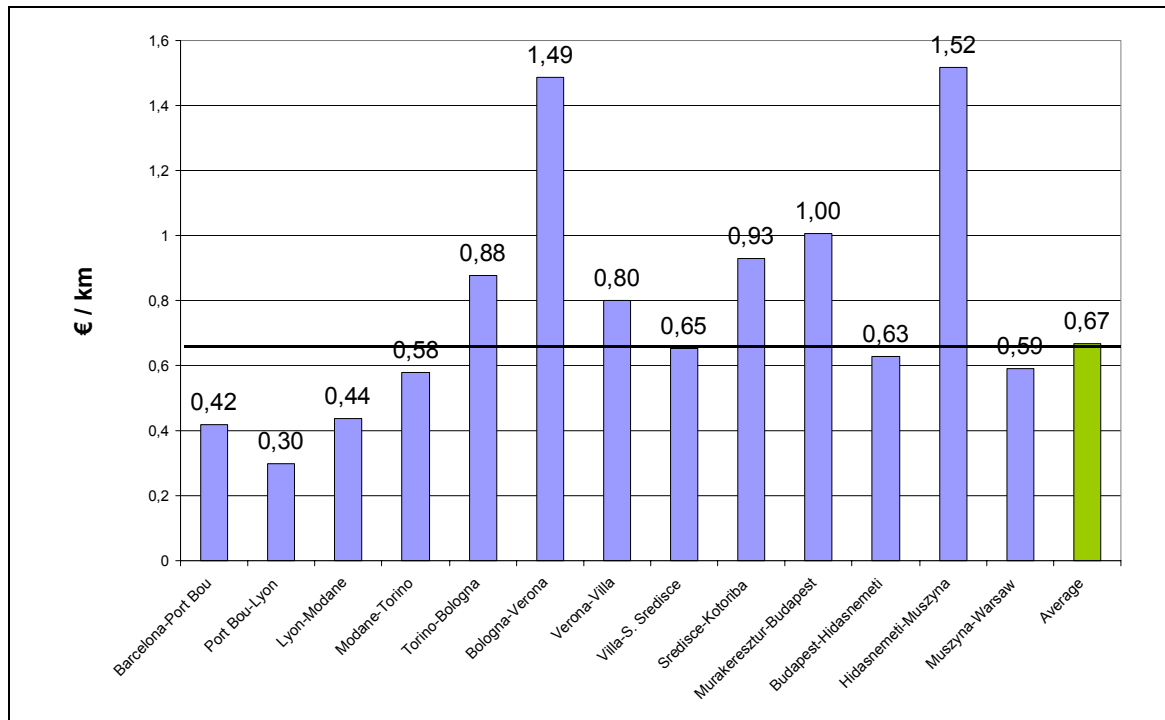
Door-to-door intermodal transport from Barcelona to Warsaw is estimated at a 3459 € level, for a Class A swap body. Rail haulage is by far the biggest component of this direct resource cost. But marketing and organisational costs (extra costs) cannot be neglected, as they represent 24 % of total direct cost.

**Intermodal transport direct cost structure
Barcelona-Warsaw, SB A, %**



A special attention can be given to rail haulage cost, which appears very different from one European railway network to another, as average cost per kilometre, for each segment, shows. The proportion is from 1 to 5, when comparing the Port Bou-Lyon segment to the Bologna-Verona or to the Hidasnemeti-Muszyna segments.

Rail distance cost (€ / km) Barcelona-Warsaw



• All-road corridor

Being along an entirely inland route, the all-road solution from Barcelona to Warsaw consists mainly in mere road haulage cost, plus a marginal extra cost for marketing and organisation (less than 1 %). The amount of the door-to-door cost is 2375 € for a class A swap body, showing a strong advantage when compared to intermodal transport, the cost of which is 3459 €. Simplicity of organisation, absence of transhipments, cheapness of haulage explain this competitiveness.

2.3.2. External cost

• Intermodal corridor

The calculated amount of external costs along the Barcelona-Warsaw corridor is summed up in the following table. The total cost is about 492 €, which can be divided into nuisances sources or into transport modes and transhipments.

**Intermodal transport external cost
Barcelona-Warsaw, € / SB A**

€/SB A	Elec-tric.	Air pollut	Noise	Acci-dents	Conges-tion	Global warm.	Pro-cess	Total
Pre haul.	0,0	16,7	22,6	127,0	0,0	7,4	4,4	178,1
Rail	48,5	0,0	19,2	77,4	0,0	50,6	9,0	204,7
Trans-ship.	0,7	0,0	0,0	0,0	0,0	0,6	0,0	1,3
Total	49,2	16,7	41,8	204,4	0,0	58,6	13,4	384,1

**Intermodal transport external cost structure
Barcelona-Warsaw, SB A, %**

€/SB A	Elec-tric.	Air pollut	Noise	Acci-dents	Conges-tion	Global warm.	Pro-cess	Total
Pre haul.	0,0	4,3	5,9	33,1	0,0	1,9	1,1	46,4
Rail	12,6	0,0	5,0	20,1	0,0	13,2	2,3	53,3
Trans-ship.	0,2	0,0	0,0	0,0	0,0	0,2	0,0	0,3
Total	12,8	4,3	10,9	53,2	0,0	15,3	3,5	100

In spite of short distances, and considering total external cost is rather modest, road contributes to external cost for 46 %, mainly due to accidents. Rail accidents also intervene (20 %), in spite of the comparative safety of this mode considering the long haulage they achieve.

• **All-road corridor**

Not surprisingly, road generates more external cost than intermodal transport, especially when, as in the Barcelona-Warsaw corridor, rail is able to achieve most of the haulage form door to door. All-road external cost (905 € for a Class A swap body) is nearly double of intermodal external cost (492 €).

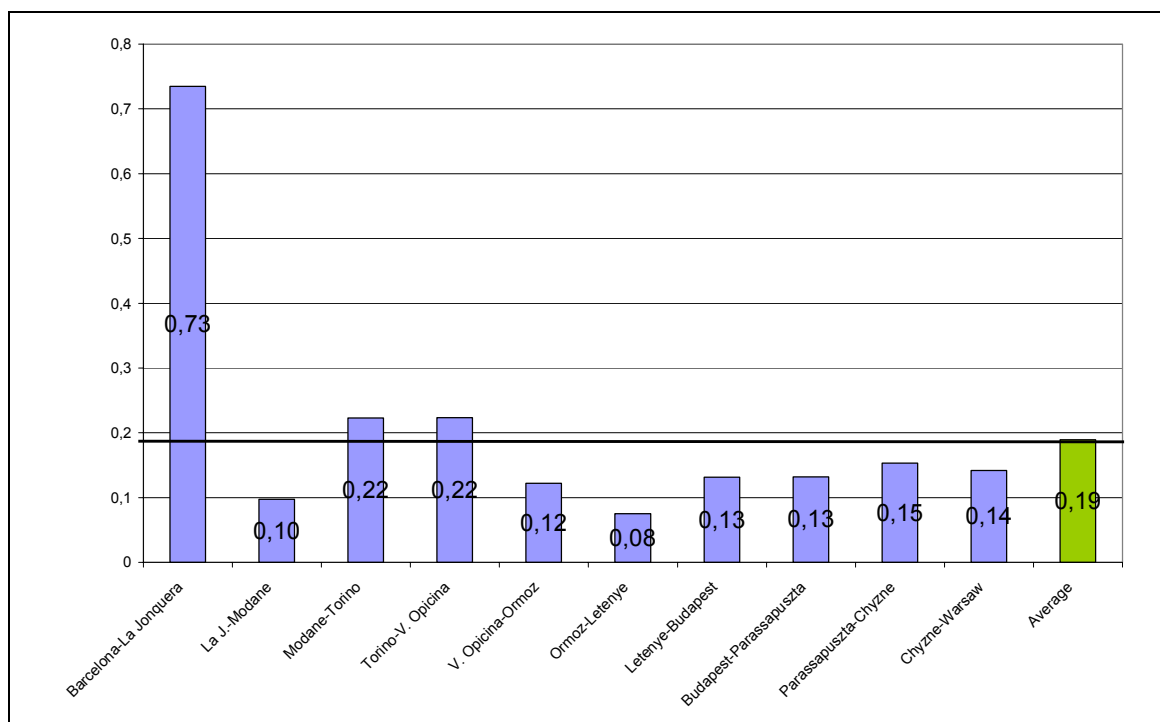
The structure of all-road external cost is as follows.

**All-road external cost structure
Barcelona-Warsaw, SB A, %**

%	Elec-tric.	Air pollut	Noise	Acci-dents	Conges-tion	Global warm.	Pro-cess	Total
Road	0,0	16,4	3,6	56,2	0,2	14,7	8,9	100

Given the weight of road accidents cost, a special attention can be given to its different levels, according to road segments along the corridor. Ratios (in € per kilometre) vary from nearly 1 to 10 ! A lot of progress can be made on most dangerous parts of the network, particularly along the Spanish segment.

**Road accidents cost per kilometre
Barcelona-Warsaw**



2.3.3. Total cost

The summing up and comparison of direct and external costs is now necessary.

• Intermodal corridor

The difference between direct cost (3459 € for a Class A swap body from Barcelona to Warsaw) and total cost (3843 €) is not very important, given the environmental friendly organisation of intermodal transport, mainly relying on rail, along this corridor. External cost only represents 10 % of total cost.

**Intermodal transport total cost
Barcelona-Warsaw, € / SB A**

€/LU (SB A)	Direct cost	External cost	Total	% Ext. cost/total
Pre and post haulage	177	178	355	50,1
Rail	2223	205	2428	8,4

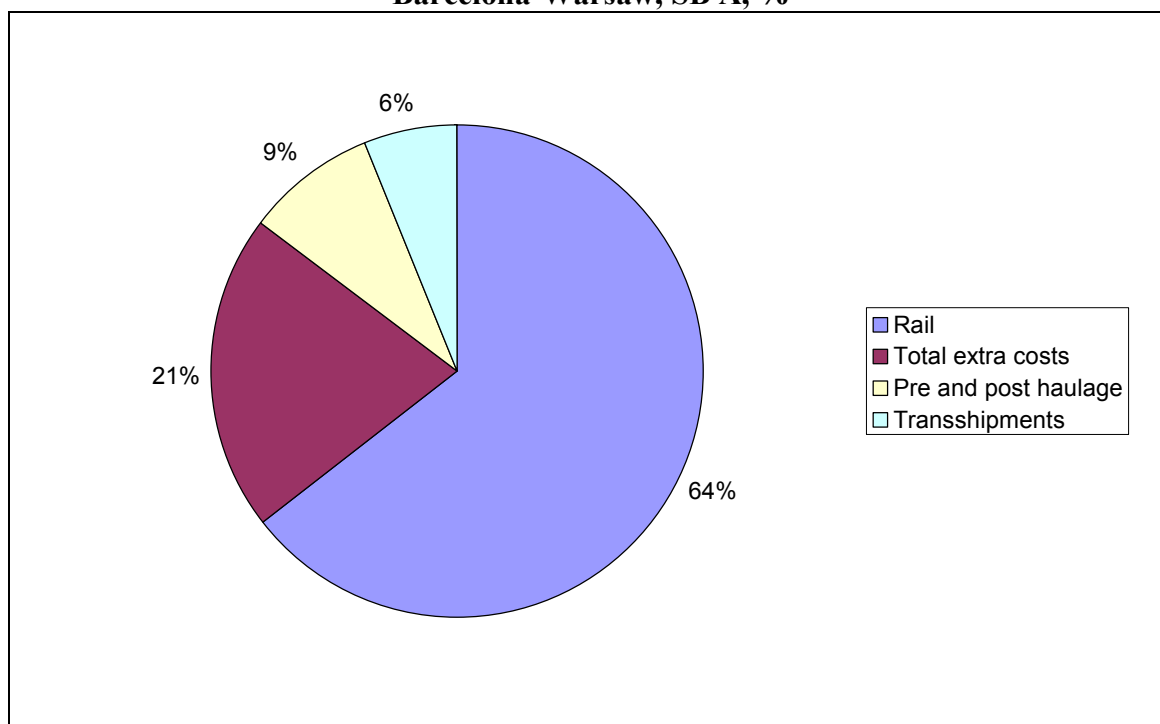
Transshipments	242	1	243	0,4
Total extra costs	817	0	817	0,0
Total	3459	384	3843	10,0

External cost is particularly heavy, concerning road pre and post haulage, as it represents the half of total cost. A calculation of percentages will underline the main items, rail haulage direct cost (58 % of total cost) and extra costs (21 % of total cost).

**Intermodal transport total cost structure
Barcelona-Warsaw, SB A, %**

€/LU (SB A)	Direct cost	External cost	Total
Pre and post haulage	4,6	4,6	9,2
Rail	57,8	5,3	63,2
Transshipments	6,3	0,0	6,3
Total extra costs	21,3	0,0	21,3
Total	90,0	10,0	100

**Intermodal transport total cost structure
Barcelona-Warsaw, SB A, %**



• All-road corridor

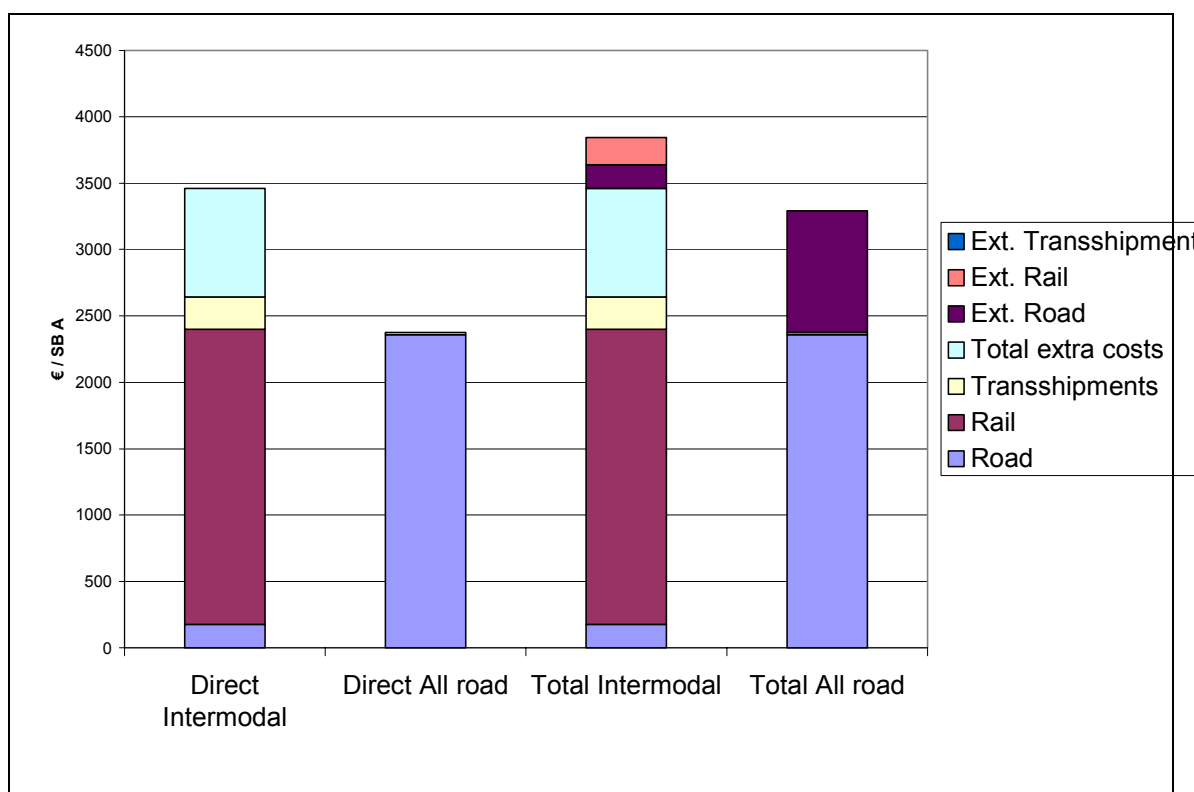
All-road solution obviously shows a rather high proportion of external cost in total cost, with a 28 % percentage. As previously seen, accidents are the first cause of road external cost, followed by air pollution and global warming effects.

€/ SB A	Direct costs	External costs	Total	% Extern. Cost
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Barcelona-Warsaw	2358	917	3275	28,0
Extra cost	17		17	0,0
Total	2375	917	3292	27,9

• **Comparison**

**Direct and total costs, intermodal and all-road corridors
Barcelona-Warsaw, € / SB A**



The comparison of intermodal and all-road solutions show that, in spite of a higher percentage of external cost, road remains cheaper considering direct or total cost. Road direct cost is 31 % lower than intermodal transport, it is still 14 % cheaper when socio-economic effects are included in the calculation. Competitiveness of intermodal transport cannot rely on a mere "internalisation of external effects". It can be a result of a steady effort to lessen intermodal transport cost, through changes introduced in all its components, or of a more voluntary planning political approach.

3. COST COMPARISON AND SYNTHESIS

The analysis of present costs (direct and external), as collected through the painstaking study of three significant, long European corridors, provides a steady basis for the next step of the exercise: the proposal of options for cost reduction. These will, of course, be determined considering the importance involved costs have in total cost and considering the margin of progress likely to be obtained.

Following the same order as the analytical phase, this step will successively tackle direct, external and total costs, for three corridors.

3.1. Direct costs

The proportions of direct costs for intermodal transport are quite different from a corridor to another but, still, show some basic issues, that can be raised for intermodal transport in general, beyond the specific cases here studied.

3.1.1. Transport operations

Transport operations (all modes being taken together) are of course the heart of the total set of services, and represent the heaviest items of its cost:

- 53 % of total direct cost on Genova-Manchester
- 77 % on Athens-Gothenburg
- 76 % on Barcelona-Warsaw.

Therefore, a decrease of 20 % of transport cost could provide a 10 % to 15 % decrease of door-to-door cost.

Those figures also mean that intermodal transport must, in addition to mere transport, bear a **non-transport cost** representing from 24 % to 47 % (i.e. between a quarter and a half) of total cost, compared with all-road solutions, the main item of which is mere haulage.

Rail distance cost shows a substantial difference according to corridors, as its amount (in € per loading unit and per kilometre) is, as an average:

- 0,29 €/LU/km on Genova-Manchester (TEU)
- 0,55 €/LU/km on Athens-Gothenburg (SB A)
- 0,67 €/LU/km on Barcelona-Warsaw (SB A).

Stronger discrepancies appear among shorter segments, the most expensive ones going up to 1,4 € per kilometre or even more. Independently from possible pricing issues from which these differences could result, such gaps (with a 1 to 4 ratio) give an idea of the

progress margin one can imagine in the future, if the best practice of cheap segments could be extended to a larger share of the network.

If one considers that a swap body of class A roughly corresponds to 2 TEU and, on this basis, one just adds distances and costs for all three corridors, representing all together a 7 531 km distance, the average **rail** cost is **0,61 €/LU/km**. Beyond the many specific local conditions this average value ignores, it can be considered as a basic cost level, on the basis of which further progress can be sought for, in order to reduce intermodal transport cost.

Among transport operations, a distinction can be made between long distance haulage and pre and post haulage, which is achieved by road.

Short sea shipping shows quite large differences: the distance cost is 0,53 €/LU/km on Athens-Gothenburg and more than the double, 1,10 €/km, on Genova-Manchester. This difference is particularly high, when one considers that the LU is a swap body of class A on the first corridor and a TEU in the second: discrepancies would be expected to be in the other way! It is difficult to draw general conclusions on the basis of so few cases, but maritime transport is not necessarily the cheap means of transport it is usually considered to be. This is even truer, as it has been seen, when one considers also external cost. Without going into further investigations, one may expect that the cost level achieved for **SSS** on the Patras-Brindisi link (**0,53 €/LU/km**) could be obtained for other links in Europe.

Inland waterway is the cheapest mode among the sample, with a distance cost of only 0,18 €/LU/km on the Genova-Manchester case (with a TEU as LU), where rail, particularly cheap on the same corridor, costs 0,29 €/LU/km. The equivalent cost of inland waterway, for a swap body of class A, should therefore be about **0,36/LU/km**.

Pre and post haulage represent some:

- 10 % of long distance haulage cost (rail, inland waterway and short sea shipping) on Genova-Manchester
- 19 % of long distance cost (rail and short sea shipping) on Athens-Gothenburg
- 8 % of long distance cost (rail) on Barcelona-Warsaw.

One must not forget that the three here studied corridors are particularly long, and sometimes complicate, compared with observed commercial traffics, from origin to destination. Therefore, percentages of intermodal chain components are altered in comparison with actual practical ones. In particular, the percentage of final haulage is here lower than in most commercial cases: the stakes of pre and post haulage reduction are all the more important.

Pre and post haulage costs are 1,31 €/LU/km on the Genova-Manchester case, and 1,45 €/LU/km for Athens-Gothenburg, compared with average distance costs of, respectively, 0,56 €/LU/km and 0,69 €/LU/km on long distance all-road solutions on the same corridors: short distance road haulage is, according to its present organisation, about twice more costly than long distance road haulage. When, using the same

calculation conventions as previously, one aggregates **pre and post haulage** for the three corridors, the average cost is **1,61 €/LU/km**.

In spite of short distances, final haulage is a heavy burden, due to inefficient organisation which diminishes the number of pick up and delivery operations a driver and a lorry can make in one day, considering the total daily cost of a vehicle is nearly fixed and is just shared between the loading units dealt with in the same period.

Long distance road haulage, prevailing for all-road solutions (or so-called all-road solutions when they have to use a ferry to cross a channel), also shows quite large differences. Its average cost is 1,13 € / km on Genova-Manchester, 0,80 € / km on Athens-Gothenburg and 0,87 € / km on Barcelona-Warsaw. The average for three corridors can be set at **0,90 €/LU/km**. This is sufficient to be cost competitive vis-a-vis intermodal transport, as all road chains are technically and organisationally simple, due to the lightness of extra cost, of transshipments, the absence of pre and post haulage. One must also mention additional competitive advantages dealing with lead-time, flexibility, tracing, etc.

The future evolution of road costs is controversial or at least uncertain. On the one hand, productivity progress observed in the passed years should go on, possibly at a slower rate: vehicles are quicker, more reliable, less energy-consuming, while commercial and logistics organisation reduces empty running and augments loading coefficients. Drivers relays also enable a more "normal" type of working conditions, the lack of manpower now demands. On the other hand, a part of road productivity results from breaches of the regulation, dealing with working and driving times, worked hours payment, load limit, speed limit, etc. A better respect of law, with adequate control and sanction, would therefore raise road haulage prices. Conscious of the destructive type of competition fraud induces, most road professional organisations now support such a policy, which should be evenly applied throughout Europe. These elements must not be mixed up with external costs and their possible "internalisation" through various means, which would also raises prices for the shipper and, consequently, strengthen alternative modes (rail, waterway, shipping) competitiveness.

3.1.2. Non-transport operations

A door-to-door transport chain does not only include transport segments. It also comprises additional non-transport operations. Some deal with physical treatment of goods, mainly consisting in handling operations of transshipment, given packaging or container stuffing are not included in the span of service. One can add to physical operations the provision of containers or swap bodies, and linked costs for maintenance and depreciation of such equipment. Some others deal with organisation and marketing, in a multi-layer organisation where forwarders sub-contract actual transport to operators, some of whom in their turn sub-contract a part of their activity to providers. The case of rail-road combined transport is characteristic of such a structure, as intermodal operators usually run transshipment yards and provide special wagons but, on the one hand, sub-contract final road haulage (or do not supply it at all, in the case of UIRR companies, the customers of which are carriers), and on the other hand buy long

distance haulage from a railway company, which itself gets its slots from the infrastructure managing entity.

Extra costs represent a substantial share of total intermodal transport cost :

- 15 % on the Genova-Manchester corridor
- 18 % on Athens-Gothenburg
- 24 % on Barcelona-Warsaw.

The average percentage, established for the sum of three corridors, is **19,1 % of total direct costs**, i.e. 23,7 % of other direct costs (other costs than extra costs). Possibly, those costs are particularly high, due to the complexity of studied corridors, and the percentage of extra cost could be lesser in actual commercial cases. It remains that a part of progress in intermodal transport cost reduction should rely on non-transport, organisational costs, and not only on haulage operations.

Transhipments are obviously necessary to intermodal transport, they are the counterpart of the ability to combine several transport modes, profiting from the comparative advantage of each of them in its relevance realm. They sometimes represent a high part of total cost:

- 32 % on the Genova-Manchester corridor
- 5 % on Athens-Gothenburg
- 7 % on Barcelona-Warsaw.

A specific effort should focus on cost driving cases, as in the Genova-Manchester corridor where transhipments are the heaviest item of the whole chain.

When one compares transhipments costs along three corridors, it appears that inland transhipments do not show a great difference (there costs vary from 14 to 50 €/LU, with an average of **29,8 €/move/LU**), whereas maritime costs transhipments are usually more uneven (they range from 21 to 174 €/LU) and more important (with an average of **77,5 €/move/LU**).

*

Even if they are a raw summary of a complex and diverse reality, the average values here calculated give a steady order of magnitude of actual direct costs of transport – intermodal as well as all road – in Western and Central Europe to-day. They will enable a simple generic comparison of both solutions, relying on a previous abundant data collection.

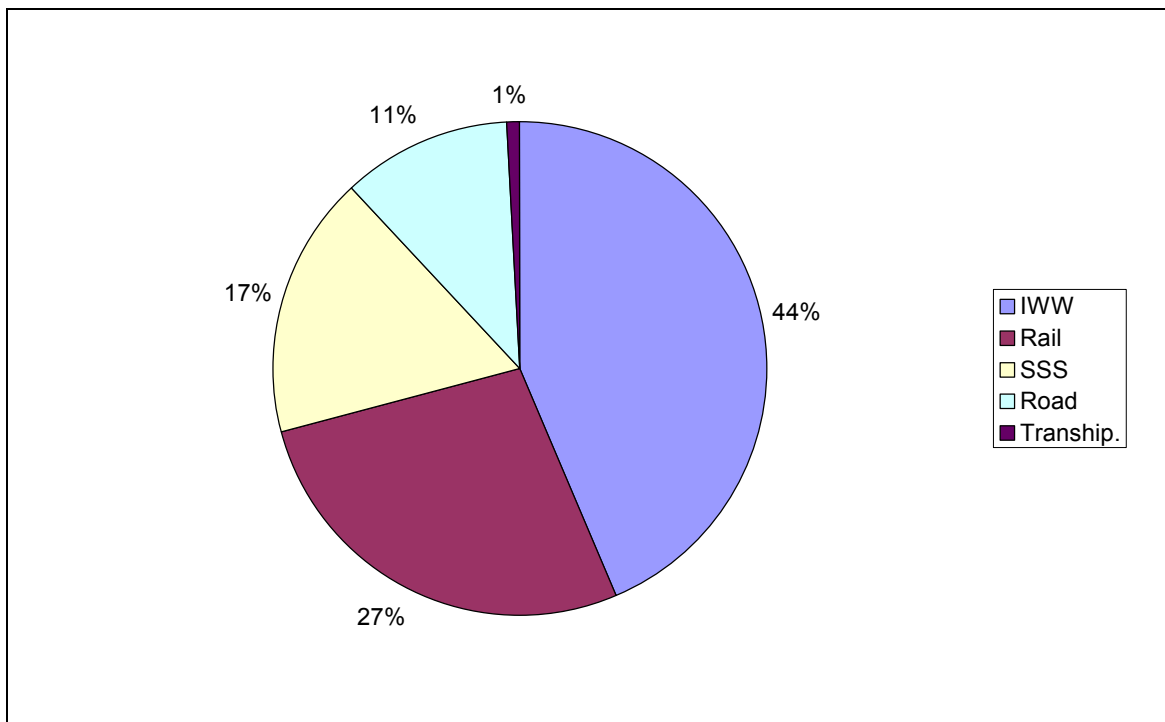
3.2. External costs

One of the main reasons why political power supports **intermodal transport** is its ability to diminish external cost, compared with often prevailing all-road solutions. Still, external costs of intermodal solutions are not negligible, as has been seen. The amount of external cost in studied corridors is:

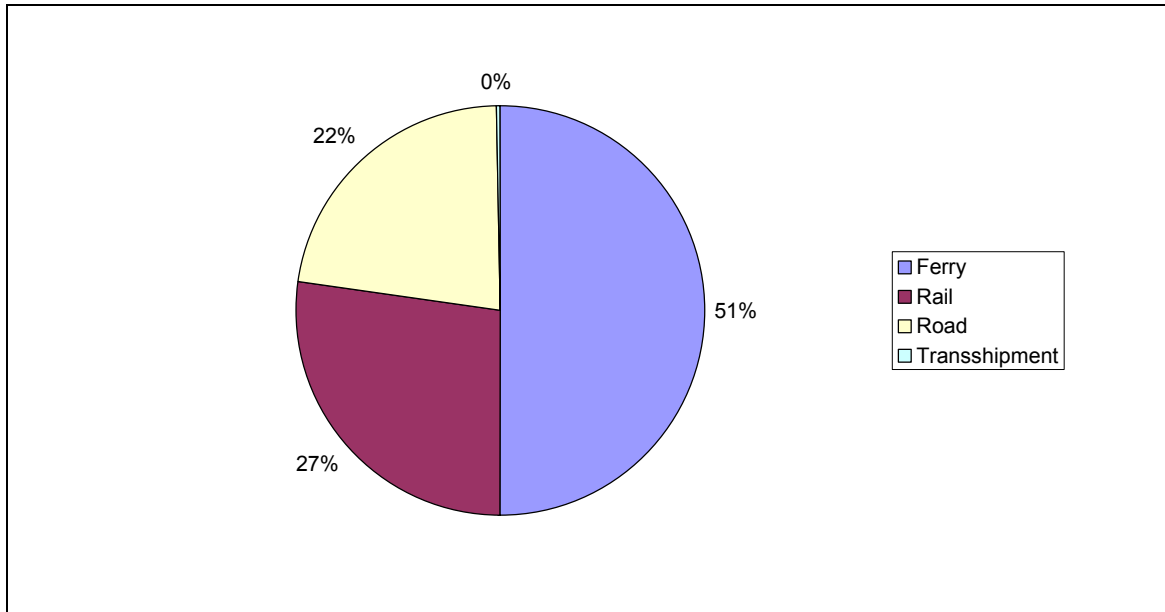
- 16 % of total cost on the Genova-Manchester corridor
- 16 % on Athens-Gothenburg
- 10 % on Barcelona-Warsaw.

These coefficients are lower than in the all-road cases. Still, an effort must be made to reduce external cost of intermodal corridors, the structure of which is as following charts show.

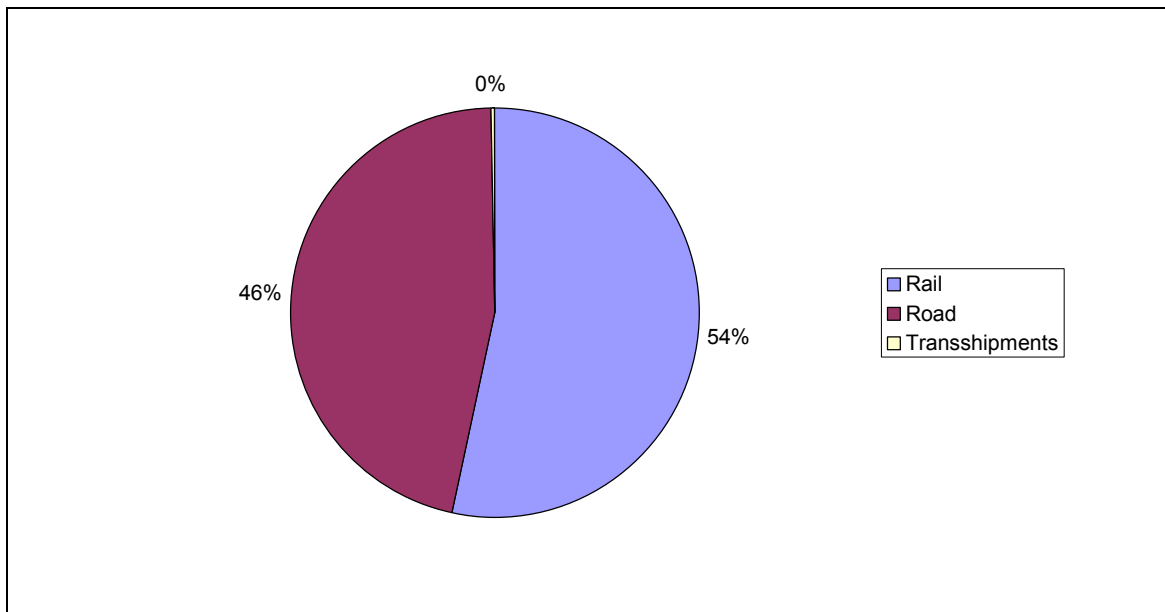
**External cost structure
Genova-Manchester, %**



**External cost structure
Athens-Gothenburg, %**



**External cost structure
Barcelona-Warsaw, %**



One notices that rail, which contributes to the whole chain for the longest segments, does not always represent the first item for external cost : inland waterway is the heaviest burden in the Genova-Manchester case, and maritime ferry in the Athens-Gothenburg one. Still, rail is not entirely environment-friendly, and progress must still be made to reduce its nuisances and external cost and make new infrastructure projects more acceptable by neighbouring population.

Summing up the three corridors, one can estimate an average extra cost per kilometre, which appears as follows:

- **rail : 0,05 €/LU/km**
- **short sea shipping : 0,58 €/LU/km**
- **inland waterway : 0,08 €/LU/km**
- **pre and post road haulage : 0,79 €/LU/km**
- and nearly nil for transshipments, and zero for extra, organisational costs.

All-road transport shows, of course, a higher percentage of external cost, the amount of which if:

- 15 % of total cost on the Genova-Manchester corridor
- 27 % on Athens-Gothenburg
- 28 % on Barcelona-Warsaw.

As an average, external costs for long distance road haulage is **0,29 €/LU/km**.

Can these percentages change in the future ? **Local nuisance** will certainly decrease, as it does for private cars, with the progressive coming into service of modern vehicles. One may think that, due to their intense use, heavy vehicle have a shorter life expectancy than private cars, and the introduction of modern equipment, reducing NOX, CO, particles, etc. is fairly quick. A substantial progress can be expected, with a reduction of noxious emissions by ten or even more. : local gas emission nuisances will shortly nearly disappear!

Noise and accidents demand further efforts, which can provide progressive results, as an extension of present trends.

Congestion is another type of problem and can be called an "internal" external cost, linked to the transport system management itself.

On the contrary, to-day's technological research seems unable to dramatically reduce CO₂ emissions, i.e. **global warming** effects. A reduction by half of emissions per kilometre, at long range (over 2020), can only be expected : nothing to do with progress dealing with local nuisances. A real change, if political decision is made of it, implies either a reduction of transport volume (unbundling of economic activity and of traffic) or, at even longer range, a shift to another energy source (hydrogen). But this would mean an industrial revolution, which seems out of the bounds of the present project.

In any case, the difference of external cost between intermodal transport and all-road transport is not as important as one might expect. The reduction of these costs is of course a relevant objective, and real success will be observed in years to come. But the simple internalisation of these costs into the price system will not suffice to change the modal choice of shippers: other tools will have to be implemented, if political decision makers choose to achieve a real modal shift in Europe.

3.3. Average total costs

Knowing direct and external costs, one can estimate an average direct and total cost per kilometre, giving a general overview of cost comparisons of intermodal and all road transport in the three corridors.

To make the exercise simple (whereas a dedicated model, taking into account all parameters and their measure, is elsewhere achieved, enabling a simulation of any type of link), the standard example here examined will be a simple inland intermodal transport, between two European regions 1 000 km far from another. One will consider that, before and after the central railway haulage (the length of which is 950 km), a 50 km terminal road haulage is necessary (the total distance, 1050 km, therefore being a little longer than as the crow flies). Two transhipments, one from road to rail and one from rail to road, are necessary, plus an additional intermediate one (considering the average distance observed between transhipments is about 400 km). In addition, to these direct operational costs one must adjoin extra costs.

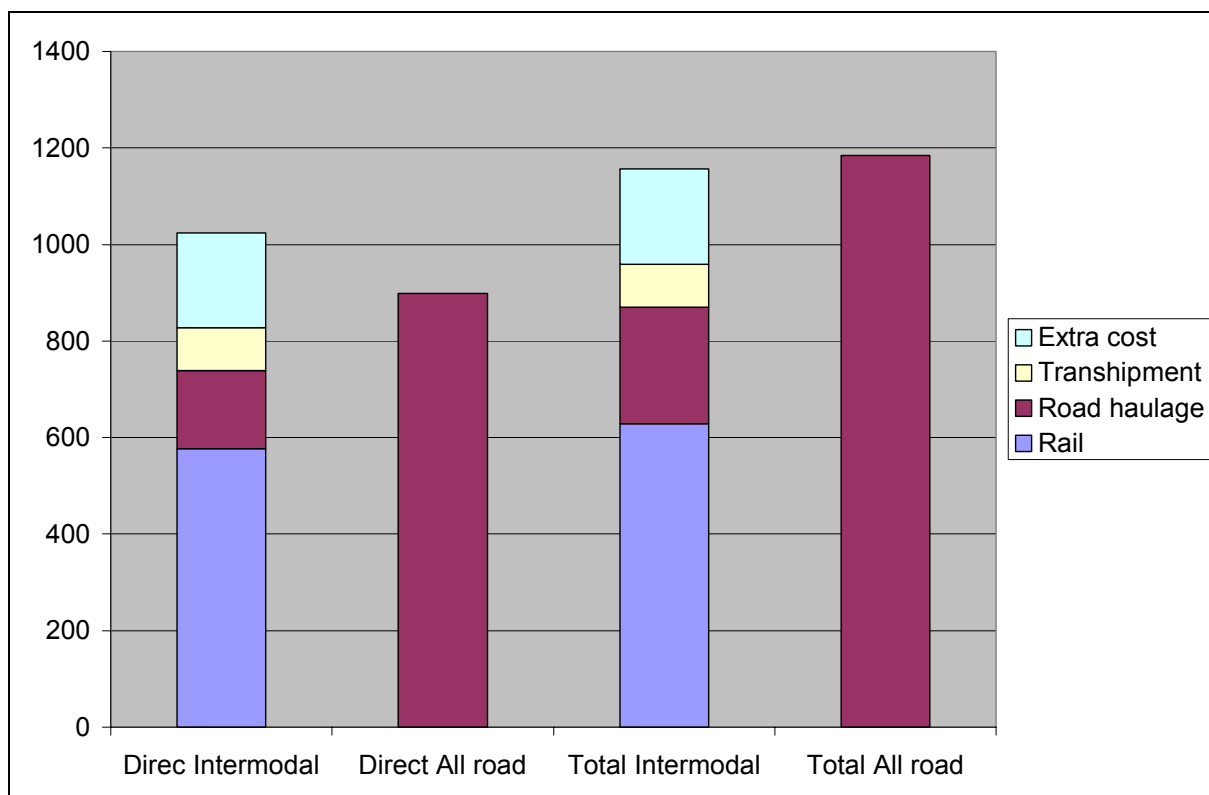
To this intermodal solution, an all road solution will be compared. It merely consists in a 1050 km direct road haulage, with no transhipment nor extra costs.

The comparison is made:

- for direct costs only
- for total costs, including direct and external costs.

The results are as follows.

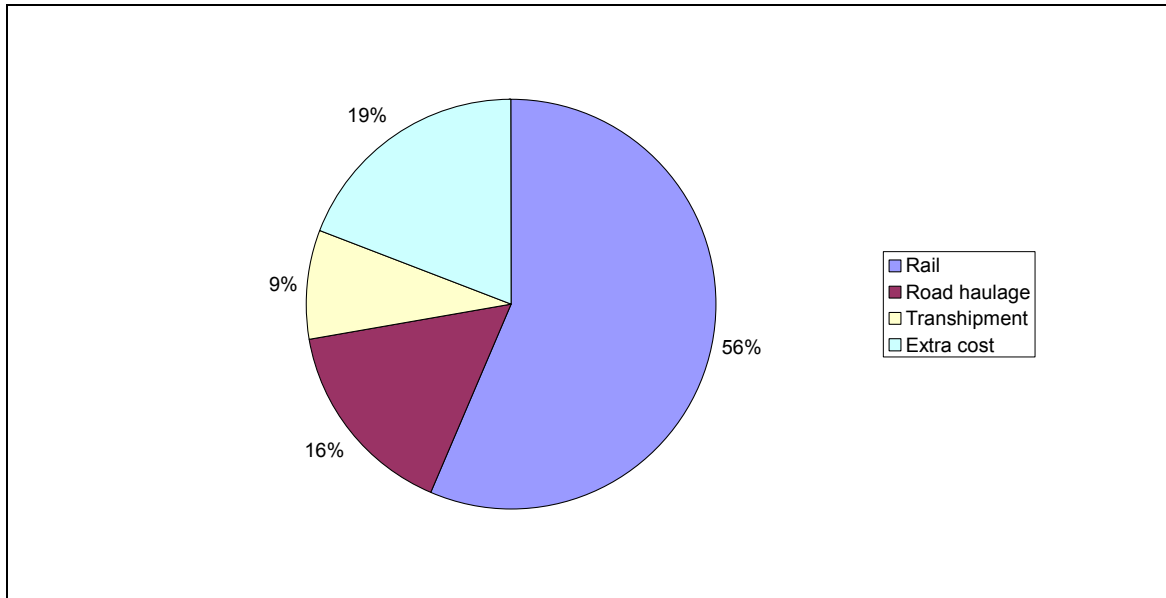
Inland intermodal and all road average direct and average total costs



These results broaden the ones deduced from each of three corridors. Direct costs show a 13 % advantage to all-road transport vis a vis intermodal solution, where the competitiveness or rail is hampered by terminal operations and organisational extra

costs. The structure of direct intermodal costs shows the weight of these charges (44 % of total door to door direct cost).

Inland intermodal transport average direct costs structure



When one considers total costs, including external costs, a slight 2 % advantage goes to intermodal transport, but this raises two observations :

- the enforcement of a political decision, including external costs into prices, is not easy to achieve ;
- a 2 % price advantage would not suffice, due to quality of service considerations, to produce an important modal shift from road to intermodal solutions.

4. COST REDUCTION PERSPECTIVES

All types of industries are involved in a permanent search for cost reduction and quality improvement, whether it results from pressure for competition on a market or from political pressure in a public utilities framework. This general trend is particularly true for freight transport.

The dominant technology for European traffics, road transport, has shown a constant reduction in its costs and prices, together with an improvement of its performances. This trend has resulted from many elements, blending technological innovation (touching vehicles, use of information technology, etc.), organisational progress (in order to reduce non productive administrative jobs, to augment the size and loading coefficient of lorries, to reduce empty running, etc.) but also some less honourable behaviour dealing with social and technical regulations (the amount of speed excess, of overloading and of overrunning work schedules cannot be ignored). In the future, several scenarios can be set up, taking into account different trends and options concerning road transport, as will be seen later.

In a highly competitive freight transport market, other techniques, particularly rail and intermodal transport, have had to cope with road efficiency and commercial aggressiveness : a service offering a lower quality level or a higher price than road has little chance to get customers... The issue of cost reduction is therefore crucial if one wants, according to a general political care for sustainable development, develop intermodal transport. Without forgetting the systems dimension of intermodal chains, which obliges observers as well as professionals to consider the relationships between actors, the same analytical approach as in previous chapters will be adopted. Standard costs, as established on the basis of three representative corridors, will be gone over again, each of them receiving a possible reduction coefficient. A door-to-door cost calculation will thus be possible, measuring the total effect of various local reductions.

Cost reduction is not only dedicated to direct costs. A substantial effort will be given to external costs, under a permanent political pressure of national and European authorities. Sustainable mobility is, more than ever, a central item of transport policies throughout Europe. Two major types of political instruments can be used to enforce such a policy. Economic incentives are first thought of, in the line of "internalisation of external effects" through price mechanisms. Fees, emission charges, green taxes are conceived, and sometimes implemented, in many countries. Tax harmonisation is, by the way, a major concern for years to come in a single European transport market. But regulatory instruments must not be neglected. After all, they are responsible for the most striking results obtained by now in reducing pollution: the progressive disappearance of old vehicles, replaced by up to date, respecting to-day's regulation with emission standards, will make the rate of pollution in European cities collapse in next to come years (apart from green house effect, which would require a reduction of carbon dioxide emission, which seems out of reach). Considering progress perspective experts have identified in this field, a reduction of external cost rate will be established for each mode analysed with studied corridors.

4.1. Rail

Rail is, in the European context, the core element of intermodal transport. Besides, a significant part of its traffic is carried out by specialised railway companies subsidiaries, or even by a special department within railway companies. It is therefore fair to insist first on rail so as to reduce total intermodal cost.

Still, one must not forget that, on the basis of Chapter 3 standard estimates, rail only represents 56 % of door-to-door direct cost. Nearly a half of this cost (47 %) is not due to the main long distance rail haulage, and must also contribute to cost reduction!

Standard direct cost being 0,61 €/LU/km, the reduction can be assessed in various means, according one elaborates a short and medium term or a long term scenario. On the **short run**, only incremental efforts and progress can be made, that will reduce rail cost by an interesting proportion. Technological and organisational means of action are numerous:

- direct physical productivity will benefit from **longer, heavier trains** (one knows that the maximum length of trains varies inside Europe, it is for example 750 m in France and 550 m in Italy). A longer, homogeneous limit would, in the same time, augment the number of loading units the same locomotive, and the same slot on the track, can deal with. In addition, it would reduce additional train sorting and resetting, with a double advantage in cost and in quality of service.
- more generally, **interoperability** is of course a main topic, the main aspects of which being the gauge, the signalling system, the electricity supply, etc. A progress with these elements will touch all aspects of railway operations, with a virtuous system effect, to such an extent that its results will probably outdo the addition of analytical advances expected from it. In the enquiry, one has discovered that, to pull a train from Basel to Antwerp, 5 locomotive changes were necessary, each of which being an additional cost and an additional waste of time... In our calculation, a transshipment is recorded every 400 km: this distance could be made longer in the future.

According to present conditions, it is difficult to precisely assess the progress one can expect from these changes. One must not forget that, as important as they will be, they will not suppress some of the major obstacles to freight rail traffic growth : the lack of vacant slots on some critical nodes or corridors of the network. Therefore, so as to remain prudent and according to expert statements, a **20 %** cost reduction assumption, in a short or medium range perspective, can be considered as likely.

Considering **external** cost, the average value of which is 0,05 €/LU/km, one can be equivalently optimistic. Rail is, by large, a sage and environmental friendly means of transportation, and progress to reduce external costs are therefore limited. Still, noise is an non negligible problem, where progress can be made, with different addition cost according to the chosen solution. Efforts can touch:

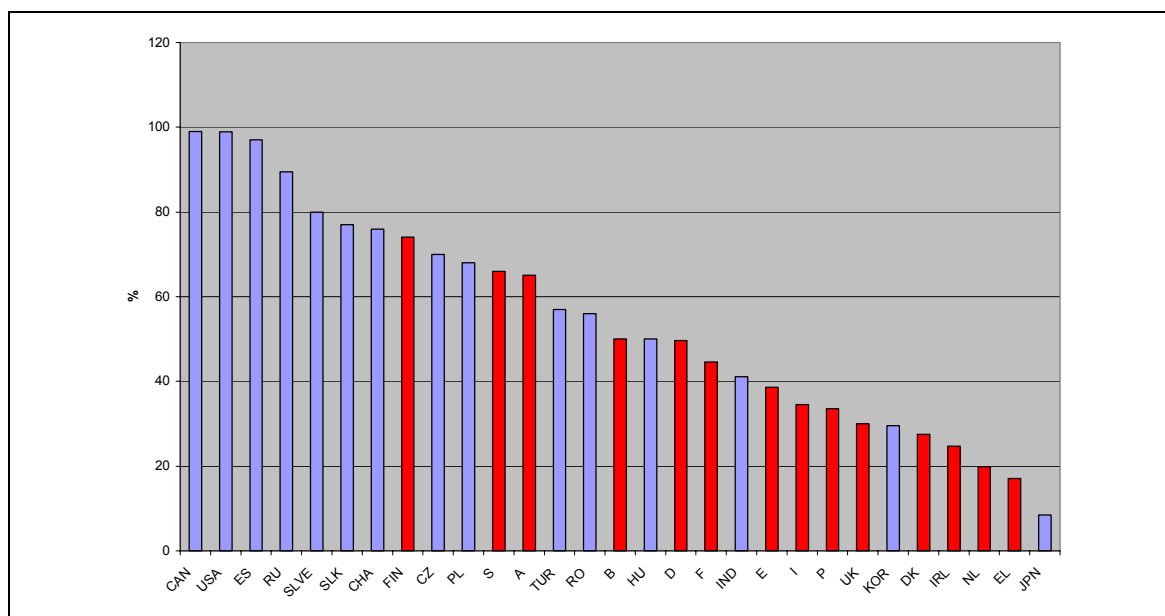
- rolling stock (locomotive and wagons, particularly wheels and brakes)
- the track (sleepers, ballast, long continuous rails)
- the isolation of the line (from soundproof walls to mere tunnels)
- diesel engines, for non-electrified lines, particularly in urban areas, can receive a special attention to diminish pollution.

A **20 %** progress can, here again, be considered as a prudent assessment.

When one considers **long range** horizons, a more ambitious vision can be adopted. The basic idea is, if not to build up a complete dedicated trans-European network for freight, at least to establish a few, majors lines reserved to this traffic. Those lines can be brand new. They can also, and often in a cheaper and easier way to achieve, previous mixed lines (for passenger and for freight trains), possibly in a too poor condition to receive modern high speed passenger trains but sufficient for heavy, slow but continuously moving freight trains. The major obstacle to freight traffic, the lack of slots and the necessity to give priority to passenger trains, would thus disappear. One thinks, of course, of the American model compared with the European one, without ignoring the simple transposition of one in the other's context is not possible. The following charts, taken from a **World Bank** general overview of railway networks, in which Eastern European and non European networks (on the left) and Western European (on the right) are usually separate, give an idea of:

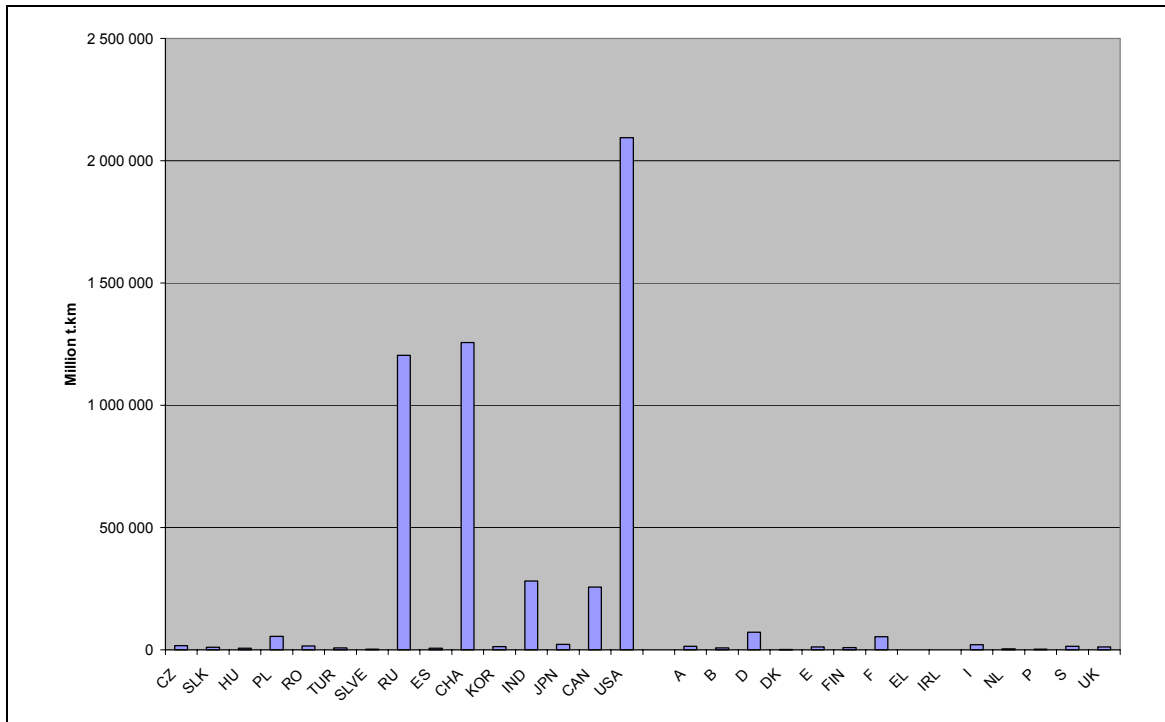
- the degree of specialisation some networks have reached (and which is not suitable to Europe, except for a limited of dedicated lines)
- the level of productivity, and therefore of cost reduction, they fulfil.

**Percentage of freight traffic to total rail
t.km / (t.km + p.km)**



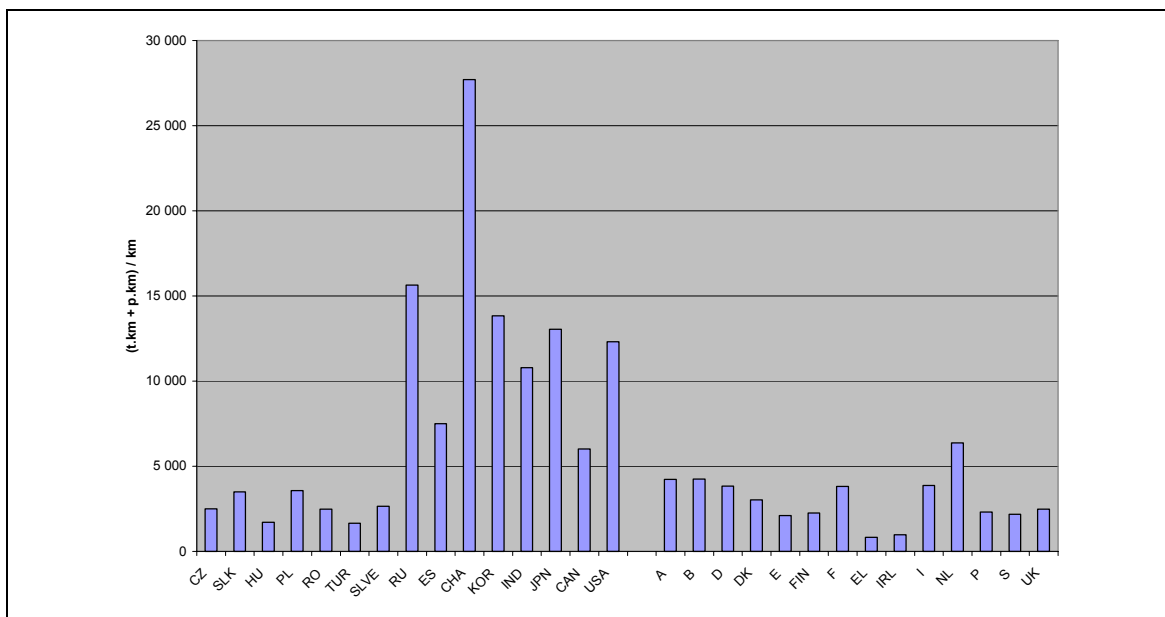
Main freight carriers in the world (USA, China, Russia, India, Canada) are massively involved in this traffic, whereas Japanese or Dutch networks nearly deal with passenger traffic only. Generally speaking, West European networks (in red on the chart) are more often specialised in passenger traffic (right part of the series) than in freight (left part), the most freight oriented ones being Finland, Sweden and Austria.

Rail freight traffic

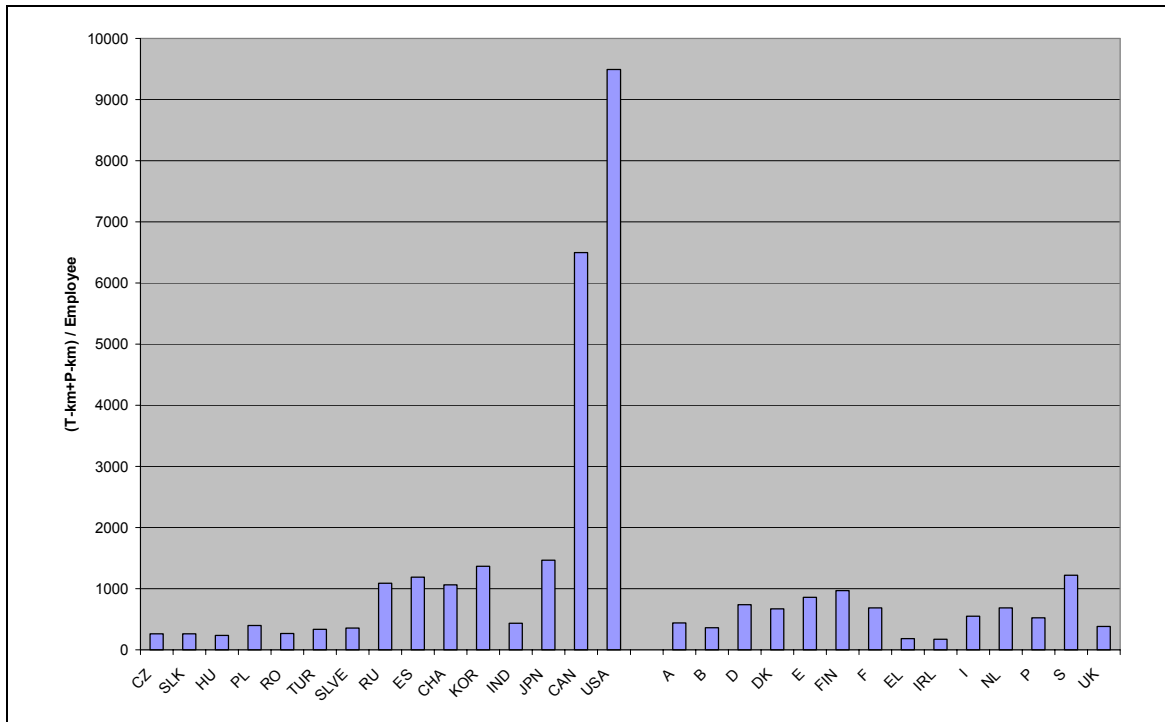


Specialisation (in passenger or in freight traffic) appears as a major factor of traffic density (intensity of traffic on the lines, which contributes to capital productivity) and of labour productivity.

Traffic density

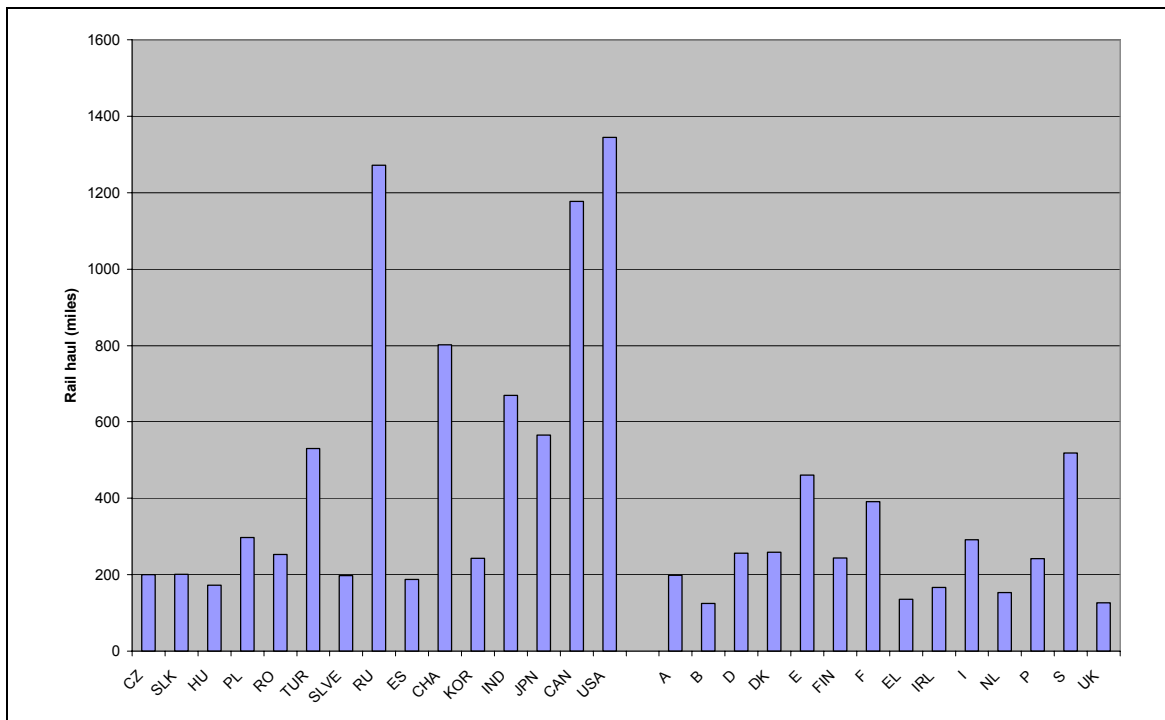


Output per employee



One notices that, apart from specialised Swedish network, Western European railways have a lower output per employee than the American (USA and Canada), but also than the Japanese, Korean, Chinese and Russian (in spite of the fall of the latest in recent years).

Average freight rail haul (miles)



In the defence of European railway companies, one must admit that, due to geographical conditions, but also due to an unfortunate border-effect limiting intra-European international rail traffic, the average rail haulage is quite short, with a strong negative consequence: rail market coincides with the market share of all road haulage much more than in American, Chinese or Russian contexts.

Anyhow, a long range scenario must include the setting up of a kernel dedicated freight network, with huge productivity progress. Even if some experts predict a division of rail cost by three, we shall only estimate progress to a noticeable **50 % gain**.

4.2 Short sea shipping

The sample of short sea shipping operations studied in this project is too narrow to draw broad conclusions from its analysis. Still, the Patras-Brindisi segment has been considered as representative of an average cost, 0,53 €/LU/km.

Progress can be made with this performance, and have been studied in several European research projects. They deal with transport equipment technology, that influence both cost productions and productivity: a faster ship can, in the same time, provide a better quality of service and, carrying out a larger number of round trips in a given time, diminish unit costs. Economies of scale are also quite appreciable, with a virtuous effect: the bigger the traffic, the lower the cost.

Another crucial issue for the success of maritime transport, included into intermodal chains, is the quality of its interface co-ordination with other links, from a technical, but also organisational, social, fiscal and legal point of view. The maritime milieu remains very specific and port communities remain very complex, heterogeneous and fragile systems, submitted to many different, and sometimes unpredictable, constraints and events that affect its unstable control. The cost consequence of these issues is important and does not only touch transport, but also related activities. In the present project, the high level of some port transshipments, the important share of total cost represented by "extra costs" reflect these difficulties. Altogether, a **20 %** progress in maritime transport cost is therefore a reasonable target.

Considering external costs, one has noticed the high level of some of them, particularly related to air pollution and global warming (0,58 €/LU/km, nearly as much as mere haulage!). Obviously, compared with inland transport, maritime transport has, by now, received little care to reduce this sort of nuisance, probably considering it took place in little inhabited zones. A development of European short sea traffic will certainly raise these issues, ports being located in urban areas. The poor performance of maritime motors leaves hope for a substantial progress. A **40 %** diminution is not out of reach,, if regulation imposes to apply available environmental friendly technology, as was successfully done for fuel consuming inland transports.

4.3. Inland waterway

Inland waterway resembles, to a certain extent, to maritime transport. Technical progress, economies of scale, co-ordination with other links of a chain can be presented in a comparable way.

Still, inland waterway costs are quite different from shipping costs. Certainly, traffic and nautical conditions are very different, and require a might lighter equipment to sail on a river than to sail on a sea. But economics must also interfere, with a very active and competitive market. The average direct cost measured in studied cases is 0,36 €/LU/km. A progress of **20 %**, combining various means of improvement, can be chosen as a calculation basis for coming years, if other inland means of transport face growing congestion and if, getting more customers, inland waterway can operate more powerful, efficient means.

Considering external costs, the average value is 0,08 €/LU/km, i.e. a quite higher standard than for rail (0,05 €/LU/km), a smaller attention having been given to nuisances in this mode than in others. Much can be obtained, and a rate of reduction of **30 %** can be accepted.

4.4. Pre and post road haulage

Pre and post haulage represents a heavy burden on door-to-door intermodal transport. For a few kilometres, a high proportion of cost, and therefore of tariffs, have to be conceded, hampering competition versus long distance road haulage: the proportion is 16 % of total direct cost, compared with 56 % for rail.

One can be surprised with the difference between short and long distance road transport costs (1,61 €/LU/km compared with 0,79 €/LU/km for direct costs), technology seeming to be about the same in both cases: same vehicles, same drivers, etc. In fact, distance cost is only an accounting average, with little economic and technological relevance. The cost of a vehicle can be divided between distance related elements, and more or less fixed elements. The former are predominant for long haulage, the later for pre and post local operations. The fixed minimal daily cost of a vehicle (including driver's wages, capital depreciation and insurance, etc.) is about 350 €, whatever traffic is carried out. If a proper business organisation enables the vehicle to treat three LU instead of two in the same day, the unit cost will be reduced by a third. One must admit that, usually speaking, the organisation of terminal road operations is quite poor. Punctuality is usually faulty, obliging lorries and drivers to wait for many hours in an unproductive way. Efforts to involve shippers, or intermodal operators' customers, in a stricter organisation have failed, the balance of power being in favour of shippers, always likely to transfer their traffic to an ever available and flexible road haulage.

Tendency to neglect this cost item is strengthened with the habit of outsourcing pre and post to small independent carriers: the poor performance and productivity is not directly born by the principal, who does not always realise a real productivity deposit is thus ignored.

Still, considering the gains that can be obtained, a really new effort can be made on this item. Existing experiences, in different countries, show that possibilities exist, to reduce

waiting time, to suppress some empty running with return haulage or with triangular route design. IT can help adapt supply to changing and uncertain demand, in an unstable urban traffic environment. Modern vehicles will also reduce consumption, maintenance expenses, etc. An important progress could be achieved, that we shall set at a **25 %** rate.

Another concern is external cost, the highest of all when comparing all modes used in our sample. The average value is 0,90 €/LU/km (18 times higher than for rail !), much higher than for long distance road haulage which mostly takes place outside of urban areas (0,29 €/LU/km). Its first explanation is accidents, which are not easily reduced, even if international comparisons show that a lot of progress could be made if existing performances in "safe driving countries" prevailed all over Europe. Other external costs items will be more substantially reduced, but a prudent **15 %** will be kept with this item.

4.5. Long distance road haulage

The prospects of road haulage costs (0,79 €/LU/km for direct costs) are undoubtedly a complex and controversial matter.

On the one hand, technological and organisational progress, which showed a high efficiency in the past, will not slow down in the future, and will go on providing expense savings.

On the other hand, several obstacles or bottlenecks impede previous trends to be simply continued. A stronger enforcement of existing, and often neglected, regulation is likely to happen, considering a stronger concern for safety, environment, etc. A part of fraudulent productivity will thus disappear. In spite of persisting unemployment, road transport faces growing difficulties in recruiting new drivers. Young generations are reluctant to accept working conditions and hourly wages out of step with "normal" jobs. Many efforts will have to be done to go past this problem : new organisation of work (e.g. relays enable daily circuits, with a return home every night, to replace former long distance driving), better training and qualification, higher wages, etc. In addition, charges and taxes are likely to augment, under various reasons.

What will be the stronger trend, between rise and decline factors ? The behaviour of shippers can be a pointer of possible prospects, as they start including transport price rise in their medium range simulations. A **10 % increase** rate will be considered in our comparisons.

In the contrary, external costs (0,29 €/LU/km) should go on decline, due to technological progress, enforced through regulation. A **20 %** progress rate, average between strong progress to be made with gas and particles emissions and little progress with dioxide, will be kept.

4.6. Transhipments

Transhipments represent about 9 % of total direct cost of a standard inland intermodal transport (with an average direct cost of 30 €/move/LU). This proportion, if not very

high, can be compared with the competitiveness gap between intermodal transport and all road solution : 13 %. Every effort on this item has to be considered.

Furthermore, transshipment often is a fragile link in a chain. It can be a capacity bottleneck, with strong influence on lead time, particularly for time sensitive traffics such as overnight services. When intermodal transport has to face all road solutions on relatively short distances, initial and final transshipment conditions often determine the feasibility of intermodal transport. Either loading time is too early, due to handling time and queuing on the yard, or unloading time is too late in the arrival yard. Time constraints are even stronger in metropolitan areas and when departure takes place in the late after-noon and arrival next day in the early morning: pre and post haulage then coincide with peak traffic hours, and are made longer with congestion and with additional precaution time. These constraints are not as stiff for long, international routes, where the lead time goes up to 48 hours or even more, and where a better spread out of activities all over the day is commercially possible: manpower and facilities work in a more continuous way, with better productivity and less stress for quality of service.

Intermediate transshipments are also a part of total cost. One has noticed that a transshipment takes place every 400 km, due to existing train scheduling, on the long corridors here examined. In past years, important research efforts were given to automation of these operations, in order to give "hub and spokes" network patterns an industrial effectiveness. These schemes turned out to be very costly and difficult to set up (some demanded a complete change in wagon rolling stock, i.e. a huge and little profitable investment), but many technological elements that had then been explored are now developed and made operational.

In conclusion, a better organisation of transshipment (mainly through efforts to augment off peak traffic, through adequate tariff incentives) and a progress in handling technologies will contribute to diminish this item. An average progress of **20 %** is accessible, as the observation of modern facilities, compared with traditional ones, already proves.

Conversely, little has to be made with external cost of transshipment, which is particularly low (given some nuisances, such as noise when yards are located besides inhabited areas, are not taken into account).

4.7. Extra costs

Last but not least, extra cost are an important progress deposit, given the high proportion of total cost these seemingly unproductive activities represent (19 %). The analytical approach followed to establish these values has shown that extra costs correspond to many, diverse functions. Generally speaking, many of them are due to conceiving, setting up, controlling, marketing services, i.e. are transaction costs. The complexity of the system, the multi-layer organisation of intermodal transport, with several embedding subcontracting relationships, explains this high amount. Certainly, the development of traffic could have a virtuous effect, new supply, and maybe new operators, involved in specific routinised door to door services, diminishing information and setting up costs.

Though, a too high diminution of extra cost coefficient should not be considered in our calculations without special care. The amount of extra cost has here been considered as a percentage, added to other operations. If a strong effort is made to reduce all these items, extra costs will not automatically diminish if no specific effort is made, as a stable coefficient would implicitly reflect! Due to important inefficiency of long complicate chains one the one hand, to the diminution of direct operational costs on the other hang, extra cost percentage, which was estimated as **23,7 %** of other direct costs, can be reduced to **15 %**.

4.8. Calculation

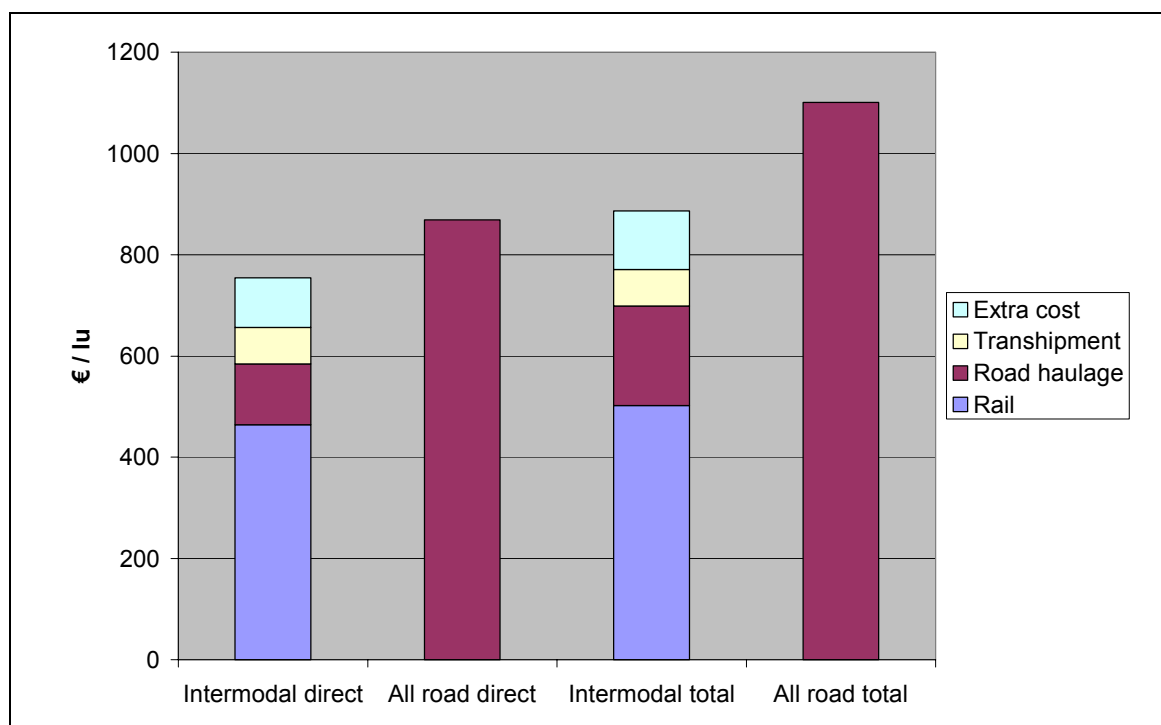
It is then possible to calculate transport cost, taking reduction rates into account. The following amounts have been accepted.

Average direct and external costs, reduction coefficients

€/LU/km	Direct cost	Reduction (%)	External cost	Reduction (%)
Rail	0,61	20	0,05	Short term: 20 Long term: 50
S. sea shipping	0,53	20	0,58	40
Inl. waterway	0,36	20	0,08	30
Pre & post haul	1,61	25	0,90	15
Long road	0,79	+ 10	0,29	20
Transshipment	30 / move	20	0	
Extra costs	23,7 % of other costs	15 % of other costs	0	

Introducing these values into the calculation of door-to-door cost for a 1000 km long inland transport (under the same assumptions as in § 3.3) leads to following results.

Medium range intermodal and all-road direct and total cost

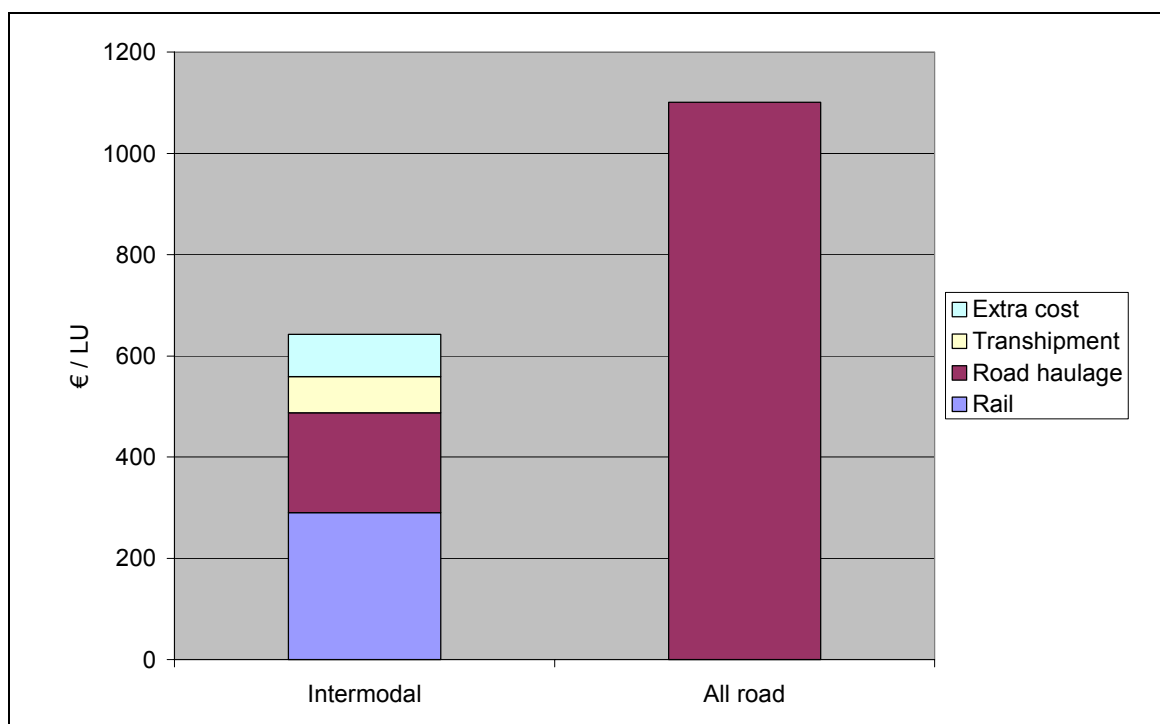


These results, which are the outcome of a long chain of observations and assumptions, are meaningful. Considering substantial progress can be made in all links of intermodal transport whereas, in spite of a continuous technological and organisational progress, road transport should not benefit from the same cost reduction in coming years, the terms of competition between intermodal transport and all-road solutions are likely to change. If one only takes into account direct costs, the advantage of intermodal transport is about **15 %**. If external costs are also included, the advantage goes up to 25 %.

These findings must be examined and the conclusions must be drawn with caution. On the cost side, the reduction here considered would result from an intense effort, involving many factors and many actors. All are not conscious of these stakes, all are not willing to co-operate or to modify their own methods (or they also have their inside blockages and obstructions, in a socially sensible and economically little profitable industry). On the market side, a 15 % cost advantage is not necessarily decisive, if quality of service is poor. To take an example in another freight market sector, one knows that some shippers prefer express parcel service to basic parcel service. They pay a twice higher price, just for a shorter lead time (one day instead of two) and more reliability. In other words, lower costs for intermodal transport would require huge efforts, and would broaden their market share but without necessarily changing market structures, with a most wanted radical modal shift. Among conditions for a decent quality of service, under the assumption of a traffic growth, is the disappearance of worst bottlenecks in the railway network. Billions of Euros are required, for investments that direct users (railway companies) or their customers (operators, shippers) will not be able to fully pay for. The debate about public financing of trans-European networks and pricing its usage in progress...

These issues are still more vibrant when one considers long term perspectives. On the one hand, cost reduction of railway operations can really be dramatic, as some examples outside of Western Europe already show. In the following chart, a 50 % cost reduction for rail haulage has been considered.

Long term intermodal and all-road direct costs



Under such conditions, and for a relatively long distance (1000 km), intermodal transport can bear its terminal and organisational costs and be competitive vis a vis road, which is 71 % more costly. Competitiveness of intermodal transport would not any longer have to be linked with external effects, so as to receive a political support, as it could be self supported on the market (assuming infrastructure pricing is treated in a satisfactory way). But this supposes the construction of a freight dedicated railway network, or the adequate transformation and assignment of a part of existing network. Certainly, a full homogeneous European freight network is an utopian scheme, but a few dedicated main trunk lines would be extremely useful considering that, as usual, 20 % of infrastructure bear 80 % of traffic.

5. CONCLUSIONS

Cost reduction is, for intermodal transport, a must. Due to its present cost structure, intermodal transport often cannot face road transport competition and, just to survive, it strongly depends on public support, through direct subsidies to intermodal operators, or through a help to railway companies, to infrastructure administrators or otherwise. In exception to its general principles which give central confidence to market mechanisms, European Commission agrees with these practices, since they contribute to develop an alternative solution to all-road freight transport, according to their concern for sustainable mobility.

The RECORDIT project has consisted in establishing, first, an acute measure of all involved costs, including both direct and external elements. The results do not exactly comply with many current opinions dealing with intermodal transport. Then, to envisage cost reduction possibilities, and their capacity to change modal split on a large scale.

Those measurements confirm that direct costs are usually higher for intermodal transport than for road. Under mere market prices, intermodal transport would have today little room in Europe. Within intermodal total direct costs, the project underlines the importance of terminal handling, of local haulage operations and of organisational and marketing extra costs, i.e. all costs coming in addition to long distance rail or waterway haulage. This means that efforts to reduce costs should not only concern long distance transport, but also all other items, which could make an all the more important progress as they have not been till now carefully examined under this respect.

Another approach deals with external costs, the current belief being that if these could be internalised into market prices, through an adequate fiscal and pricing system, the terms of competition would be transformed, the behaviour of shippers would be modified and modal split of freight traffic would find a new, preferable, balance. The point is that external costs are not as important and not as uneven as one often thinks. The average ratio of external cost related to total cost is about 27 % for road transport. But it is still about 17 % for intermodal solutions, which is not as environmental friendly as expected. The advantage for intermodal transport, under the very strong assumption of internalising external costs, would therefore not be strong enough to spark a massive modal shift off.

All these results show that the expansion of intermodal transport cannot only proceed from a change of fiscal and infrastructure pricing practices. A strong, internal effort of direct cost reduction is necessary, which can only result from technological, organisational and social progress, in a complex and sometimes opaque system, involving many actors whose short term interests are not always convergent. At medium range, a substantial result can be obtained, which would make intermodal and road costs closer, with even a slight advantage to intermodal solutions. Competition would be better balanced. But costs considerations should not keep quality of service matters in oblivion, as many shippers, in a lean production management scheme, also consider flexibility, reliability, tracing and lead time as modal choice criterion, besides price.

On the long run, perspectives are more uncertain, but room for manoeuvre is also wider. Road transport can make further progress (due to technology, to regulation of size of

vehicle, to information technology and logistics management, etc.), but several constraints might also get stronger, due to congestion, energy and infrastructure pricing, working conditions regulations and manpower shortage, etc., so that long range tendency is not necessarily cost decrease, as it has always been. On the contrary, radical changes in railways can occur, if a dedicated network is set up for freight traffic, at least on major trunk lines, enabling the type of operation one can observe the success of in such countries as the United States, Canada or even Russia. In such conditions, rail and intermodal direct costs can be dramatically reduced, and allow a self supported competitive growth. But this presupposes a huge investment effort, European and national budgets were, till now, unable to achieve. Maybe, the White Paper concerns will give such a challenge, in coming years, a stronger political relevance.

RECORDIT project cost accounting and cost reduction scenarios show that there is no miraculous hidden solution, the discovery of which would give a rapid solution to old problems. But ways of progress are certainly possible, that require unprecedented efforts. As the title of the White Paper says, it is time for choice...
