COMPETITIVE AND SUSTAINABLE GROWTH (GROWTH) PROGRAMME

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UNIfication of accounts and

marginal costs for Transport Efficiency

Annex A7

Deliverable 10:

Mediterranean Short-Sea Shipping including Piraeus Port Marginal Cost Case Study

Version 1.1
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1. Introduction

1.1. Short- Sea Shipping

Short- Sea Shipping plays a vital role in the international movement of goods and passengers within Europe, a role that is increasingly recognized and understood by European policy makers. Short-Sea Shipping enjoys increasing attention, as the promising and alternative transport mode in Europe, notably from policy makers and national governments and E.U. institutions. There are three main factors point to the increasing development of Short-Sea Shipping[1]:

- Political developments
- Economic growth, which results in ever, more bottlenecks in land transport modes and the increasing demand for transport services.
- Natural advantages over transport modes as being the most cost effective with regard to investments/capacity, environmental friendliness, energy efficiency, effectiveness for development of peripheral areas and the natural infrastructure.

During the last few years, the European Union has put a strong emphasis on short-sea shipping by recognizing it as one of the transport modes besides rail, truck and barge. This has led to the necessity of drawing a distinction between Short-Sea and other types of shipping.

"Short-Sea Shipping" means the movement of cargo and passengers by sea between ports situated in geographical Europe or between those ports situated in non-European countries having a coastline on the enclosed seas bordering Europe[2]. Short-Sea Shipping includes domestic and international maritime transport, including feeder services, along coast and to and from the islands, rivers and lakes.

The term "Short Sea Shipping" (SSS) has been defined as including all sea transport which does not require ocean-crossing voyage. Thus, Short-Sea ships are sea-going cargo carrying (including passenger carriers) of less than 5000 GT. Ships of less than 100 GT, non-propelled vessels, and harbor or inland waterway service vessels are not included.

SSS could be described as re-active, although it is confronted with very active competitors, namely the road mode and in some cases the rail mode. The lack of efficient marketing also contributes to the negative perception among shippers on the maritime sector. There is a feeling that a liberalized market without government

[1] European Short Sea Shipping: Proceedings from the First European Research roundtable conference on Short-Sea Shipping, 1993

[2] EC COM (1999) 317, Final

intervention would force the SSS-operators to promote their mode more effectively and efficiently.[3]

1.2. Objectives of the Case Study

The main objective of this case study is the estimation of marginal infrastructure costs concerning Mediterranean Short-Sea Shipping, mainly concentrating on the largest Mediterranean Port, Piraeus. Starting point of the estimation of marginal cost is the description and analysis of the cost structure of infrastructure services produced by Mediterranean Short Sea Shipping. For this purpose also the main infrastructure elements used in production of port services are identified.

It will also be "investigated" if and how the tariff policy of the SSS services and the tariff policy of port operations are related to marginal costs.

1.3. Scope of the Study

Ports produce passenger and freight services with the interchange between maritime and surface transport. This requires port's infrastructure to be able to supply a complex mixture of different kind of activities and items. In this kind of framework it would be uninformative or even ambiguous to formulate a single cost function for all port activities. Therefore, theoretically the more adequate way to model the cost structure of ports is to use a separate cost function for each activity.

The method used in this study is based on disaggregating of accounting cost data by categorized activities and related cost drivers. The outcome of the study is not a statistical relationship between activities and cost drivers, but a practical application based on a technical/engineering approach. The study contains the following main steps:

1 Description of port operations and relevant costs:

- Identification of main infrastructure elements.
- Identification of main infrastructure costs (measurement)

2 Identification of the output data

3 Identification of marginal cost elements:

- Identification of marginal and fixed costs by activities,
- long-run versus short-run marginal cost

4 Estimation of relevant marginal costs, engineering approach:

- Integration of steps 1,2 and 3 above

[3] C. Peters, A. Verbeke, E. Declerq, *European Short Sea Shipping: Towards the 21st century*

- Alternative approaches for MC

5 Generalization of the application results:

- Piraeus port,
- Mediterranean Short-Sea Shipping

2. State of the Art Review – Marginal Cost Principles, Cost Practices

2.1. Basic Principles for Marginal Cost

The decision which cost elements are within or out of the scope of the marginal cost analysis in UNITE project has in case of infrastructure costs to be made along two lines: The first line has to be drawn along the type of costs (or cost elements) while a second line has to be identified along asset types.

To start with the type of costs it is obvious that total infrastructure costs consist of

1. Capital costs for
   - new investments
   - replacement of assets
2. Running Costs for
   - maintenance
   - operation
   - administration.

Within the scope of marginal cost analysis all infrastructure costs which can be identified to vary with traffic volume. Additionally also parts of investments to replace assets might vary with traffic volume. Therefore also capital costs for replacement of assets will be included in the marginal cost analysis. This implies vice versa that capital costs for new investments and overhead costs assumed to be fixed and would thus definitely be excluded. However, while for parts of the running costs (for example for maintenance costs) the variation with traffic volume is obvious, there are also cost elements where the relationship to traffic volume is rather indirect or only party given.

The following items are out of the scope of the marginal cost analysis:

- fixed costs (capital costs for new investments, overhead costs),
- certain assets such as parking houses, which can be assumed to have fixed costs only (e.g. not much cost variability with traffic volume),

- assets costs which relate to supplier operating costs (i.e. ticket selling facilities),
- non-transport related assets such as shops, restaurants etc. in airports and rail stations.

To produce the above outputs and to facilitate port operations, a variety of inputs are required. Based on the production framework, port inputs can be generalized as land, labor and capital. The major capital inputs in port operations are the number of berths, cranes and tugs. The most fundamental labor input is the number of stevedoring labor. However, due to a lack of information on this particular variable, a proxy variable is used represented by the number of port authority employees for the respective ports. This proxy variable is less difficult to obtain because it is usually published in the annual reports of some ports. With respect to the land input, the study uses the terminal area of the ports. Another important factor influencing port outputs is the amount of delay time, which is the difference between total berth time plus time waiting to berth and the time between the start and finish of ship working, and is an indicator of how well working time is being used. These delays could be due to labor disputes, work practices such as meal breaks, equipment breakdown, and port congestion, perceived ship problems or bad weather.

According to the international bibliography[4] the most appropriate pricing policy for the *port authority* should be that of a state enterprise, while the port operators, should price as conventional business undertakings. In broad outline the following principles should apply:

1. In respect of the supply of infrastructure, facilities and services that constitute either a natural or technological monopoly, the overall revenue should be sufficient to defray the long-term marginal costs. Those costs will include the costs of the capital employed and the depreciation of the assets, as well as the costs of personnel, maintenance and other services associated with the supply.

2. Pricing should be based on the short-term marginal cost (or directly attributable cost) plus a contribution towards the fixed or indirect costs according to the value of the use of the infrastructure or facility, or the service rendered to the beneficiary.

3. When the technology involved and the structure of the market allows adequate competition in the supply of port facilities and services, then the pricing of the supply should follow business principles. By "adequate" competition is meant that either the actual competition in the market or the threat of competition is sufficient to ensure that monopolistic profits cannot be made. It is obvious that the supplier of port facilities and services in those circumstances will need to observe different accounting conventions and operate under a different status to the supplier of port infrastructure constituting a monopoly.

[4] International Conference on Shipping, Ports and Logistics Services, organised by the International Association of Maritime Economists, Vancouver, Canada, 1996.

4. The revenue should be sufficient to defray the long-term marginal cost, should apply to national ports jointly, if those are to operate as complimentary ports.

5. The contribution of one port to the fixed or indirect costs of all national ports will not necessarily be pro rata to the investment in that port or to any other port or be based on any other national criterion beyond the value derived by the port user or beneficiary.

6. It is evident that for the case of ports with excess of capacity, each additional user does not require new infrastructure, so in that case Marginal Cost Capacity (MCC) = 0 and the long-run and short-run marginal costs are equal, where the latter cost is formed only of maintenance and infrastructure repairing costs. Meanwhile, for the case of a port with congestion problems, the marginal cost of capacity has a positive value, and therefore LRMC>SRMC.

In principle, the overall purpose is to enable the productivity of the ports to be determined by competition in the intermodal transport of cargo from origin to destination and *to ensure that the carriers have control over the costs* throughout the movement of the cargo.

The foregoing principles proceed from the premise that port authorities are public enterprises, which should behave as such. That requires their prices to be based on marginal costs, which in theory is the correct pricing policy for state enterprises, on the assumption that economic efficiency demands that the users of a service pay the marginal cost of the production of whatever they consume.

In practice, strict marginal cost pricing is virtually impossible and adjustments must inevitably be made to obtain a second best solution. One of the first questions that arise is whether marginal cost pricing should be based on long term or short-term costs. The long-term marginal cost concept becomes relevant when economies of scale can be achieved and the capacity meets the demand. If the capacity exceeds the demand, as it normally does within ports, then the optimal price will always differ from the long-term marginal cost. Therefore, many economists consider the issue of economies of scale as irrelevant and maintain that port pricing must be based on short-term marginal costs.

However, there are some difficulties when implementing long-run marginal cost pricing in practice –common to other industries- and these are: (1) the infrastructure cannot be enlarged in a continuous way (there are indivisibilities derived from the minimum size that have a long economic life. If that rule of setting price equal to long-run marginal cost is directly applied, port tariffs could oscillate widely between years, since those users that call at the port in periods of capacity enlargement would then be paying for some assets that are to be used also in the long-term.

In practice[5], a solution is to use some formula to distribute the cost of construction and its associated financing cost (payment of interest on loans) during the economic life of the asset. Thus, it is estimated what part of the total cost of capacity should be

[5] L. Trujillo, G. Nombela, " Privatization and Regulation of the seaport industry", 1996

paid by port users each year, so that port tariffs do not vary much, and at the end of the period the users have financed the asset.

As an example for a possible formula to use, consider the case of a seaport in need of an investment of amount *I* that is completely financed by a loan with an annual interest rate equal to *i*. Then, it is possible to calculate a constant annual payment *rI* such that at the end of the period of *n* years estimated for the asset life, the loan and its associated interest payments would be completely repaid. The unit repayment cost *r* would be given by the expression:

$$r = \frac{(1+i)^n \, i}{(1+i)^n - 1} \tag{2}$$

Once that the part of total capacity cost for each year *t* is computed, the marginal cost of capacity can be approximated dividing it by the increase in the level of port activity (*Q*) for each period:

$$MCC_t = \frac{r\,I}{Q_t - Q_{t-1}} \tag{3}$$

In the case of a port's enlargement that involves several projects to build infrastructure and superstructure elements, which can be entering into service at different dates, taking averages to avoid jumps in the port tariffs during the construction period can modify the definition above.

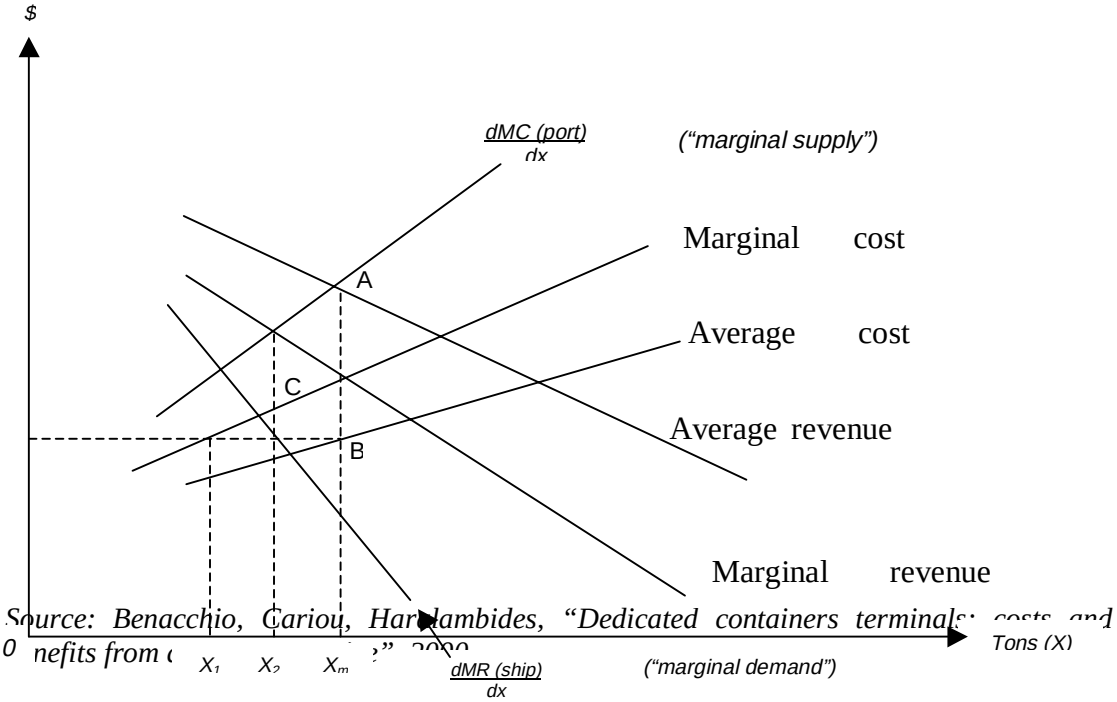
2.2. Cost Practices

The port produces a wide variety of services, each with its own unique competitive conditions. Consider first, for example, the docking and quay facilities of a port. Clearly the substitutes for such facilities can only be docks and quays elsewhere, that is to say, a competing port. Private entrepreneurs or truckers on the other hand can more or less equally well provide the storage facilities that are provided by the port. Thus there is great competition in the supply of storage, and the port may be considerably constrained in its charging practices. These constraints operate whether or not the port as a supplier of bonded storage is protected by the existence of customs duties coupled with high interest rates. The elasticity of demand for the services of the transit shed as such may, therefore, be very high indeed. Even for quay occupancy there may be considerable opportunities for substitution. The most dramatic examples of these effects are in the use of palettes or other more advanced unitized methods of cargo handling. There is, furthermore, a high degree of substitutability between ship's gear and port cranes. Similarly, there is the choice between working cargo alongside the quay and loading or unloading over the side into the lighters that have access to shallow berths or that may distribute it directly to private wharves.

The substantive issue is that the port services consist of an a la carte selection rather than a fixed menu. Even though a ship owner is compelled to patronize the port, there are many opportunities for cost-reducing substitutions. These opportunities vary considerably according to the time allowed for adjustments. Some may

involve the adaptation of equipment of a vessel, and others may involve building a different type of vessels. Therefore, the fixed proportions model is unlikely to be appropriate for most ports and leads to a serious underestimation of the long-run elasticity of demand for the services of the seemingly monopolistic port. The difficulty with this port-charge / freight-rate relation turns on the competitive structure of the shipping industry. If one monopolist firm serves the country and if the port industry is organized also as a state monopoly, a bilateral monopoly emerges.

The natural outcome of bilateral monopoly, according to a standard theorem of economics, is the production of that volume of output of the intermediate good or service that maximizes the joint profit of buyer and seller. This result is reached by an all-or-nothing deal (or simply, discriminating monopoly): the stronger party to nothing. An all-or-nothing bargain forced by, say, the strong port on the weak shipping monopoly would dictate that the ships must buy that volume of port services (Xm) for which the port's marginal cost equals the ships' marginal revenue product. (see figure next).



Source: Benacchio, Cariou, Haralambides, "Dedicated containers terminals: costs and benefits from c[illegible]," 2000

This same transaction would come about between the departments of a profit-maximizing enterprise consisting of a port-plus-shipping company. But the price paid by the ship would be fixed by the strong port at $A per ton, equal to the ship's average revenue product which excludes profits. Alternatively, a strong ship

confronting a weak port would offer a price of only $B per ton for the same quantity of X_m tons annually and would enforce this deal (and a price at which the port would normally only wish to supply X_1 tons of service annually) by the treat of not calling at this port at all.

This solution, implying the output X_m and an indeterminacy of price between $A and $B per ton, is only feasible to the extend that all-or-nothing deals are feasible in the market for port services. The most obvious opportunities for this type of bargain exit in the dealings between ports and container consortia. Consortia bargain for separate

terminals in the ports and will seek to obtain this at a profit. But varying the competitive mix of the shipping interests confronting the port, if this is at all practicable, requires a long-run strategy. The question of charging systems and cost recovery practices for the use of transport infrastructure has been addressed by the Commission's "White Paper on Fair Payment for Infrastructure Use". It is again important to underline the apparent discrepancies in Member State replies on the level of investments carried out by the public sector Hence the question of cost recovery cannot be satisfactorily and comprehensively examined when there are serious doubts about one important element of the equation, i.e. the cost side.

3. Case Study Methodology

3.1. Construction of Database

3.1.1. Mediterranean Short Sea Shipping (SSS)

The fact that no official balance sheets were available for the Mediterranean ports except Piraeus, led to the elaboration of existing data on investment financing of the European Community ports.

Hence, the marginal costs were derived, following several assumptions from the tables 3.1 to 3.11 that provide such data.

Public financing per investment category for all the EU ports

The Commission services undertook a grouping of Member States replies on public financing in accordance with the investment categories as established in Annex II of the questionnaire for the completion of the Inventory. The following Table 3.1 summarizes the amounts spent for the period 1995 to 1997 in million €:

Table 3.1: Port Infrastructure investments

Investment Category as per Annex II of the Questionnaire	**1995** (Mio. Euro)	**1996** (Mio. Euro)	**1997** (Mio. Euro)	**Split per investment category (1997)**	**Evolution 1995-1997**
1.1 – Land purchase	29,0	19,0	69,4	4%	139%
1.2 – maritime access	107,7	89,0	77,1	5%	-28%
1.3 – Port infrastructure	327,0	379,0	507,6	32%	55%
1.4 – Port superstructure	338,0	280,5	358,4	22%	6%
1.5 – Infrastructure links	45,5	40,0	24,1	2%	-47%
1.6 – Port maintenance works	169,1	211,1	219,1	14%	30%
1.7 – Port services	233,7	328,2	305,2	19%	31%
1.8 – Other port activities	38,2	43,2	35,7	2%	-7%
Total public financing	1.288,2	1.389,9	1596,6	100%	24%

Source: EC WORKING PAPER ON PUBLIC FINANCING AND CHARGING PRACTICES IN THE COMMUNITY SEA PORT SECTOR, 1998

In analyzing the above data it is worthwhile noting that:

- The public monies included in this exercise cover only 52 major ports in the Community. There are more than 350 Community ports susceptible for public financing under the **T**rans **E**uropean **N**etwork programmes.

- A public financing of approximately 3 to 5 billion € per annum dedicated alone to ports shows thus a considerable 5 to 10 %-share for these investments from the Community budget for transport investments

- The low levels and/or decreasing trends of typical 'start-up' investments such as expenditure on land purchase; basic maritime access and infrastructure links seem to confirm that the port industry in most parts of the Community can be considered mature. These three investment categories represent only some 11% of total public financing for ports.

- On the other hand there is a dominant position of port infrastructure investments (32%), which also shows one of the most prominent growth rates among the various investment categories. This may reflect significant constructions in existing port areas, with major public spending on infrastructures such as internal locks, docks or quay walls. In addition the construction of the new port of Gioia Tauro has resulted in the increase of investment costs.

- Investments in port superstructure and port services, which are also indicators of expansion in existing capacities and/or improvement in efficiencies, represent together the major part of public support for ports (41%). In addition, this public support has shown significant growth in both absolute and relative terms.

Public financing per EU region

The distribution of total public investment made in ports in major maritime regions in the Community is shown in Table 3.2, based upon Member States replies to the questionnaire:

Table 3.2: Total public investment per major maritime region

Maritime Region	**1995** (Mio. Euro)	**1996** (Mio. Euro)	**1997** (Mio. Euro)	**Regional split (1997)**	**Evolution 1995-1997**
Baltic	216,9	217,5	307,3	19%	42%
North Sea	801,2	921,4	1002,9	63%	255
Atlantic	91,2	65,5	64,5	4%	-29%
Mediterranean	179,5	185,6	221,8	14%	24%
Total public investment	1.288,8	1.389,9	1.596,6	100%	24%

Source: EC WORKING PAPER ON PUBLIC FINANCING AND CHARGING PRACTICES IN THE COMMUNITY SEA PORT SECTOR, 1998

The following tables indicate the evolution of public investment per maritime region and major investment categories.

Table 3.3: Public investment in typical "start-up" investments (land purchase, maritime infrastructure, infrastructure links)

Maritime Region	1995 (Mio. Euro)	1996 (Mio. Euro)	1997 (Mio. Euro)	Regional split (1997)	Evolution 1995-1997
Baltic	5,1	7,5	39,2	23%	671%
North Sea	122,1	85,9	80,5	47%	-34%
Atlantic	12,8	11,5	11,6	7%	-9%
Mediterranean	42,1	42,9	39,2	23%	-7%
Total public investment	182,1	147,9	170,6	100%	-6%

Source: EC WORKING PAPER ON PUBLIC FINANCING AND CHARGING PRACTICES IN THE COMMUNITY SEA PORT SECTOR, 1998

Table 3.4: Public investment in port infrastructure

Maritime Region	1995 (Mio. Euro)	1996 (Mio. Euro)	1997 (Mio. Euro)	Regional split (1997)	Evolution 1995-1997
Baltic	16,2	15,7	12,3	2%	-24%
North Sea	202,5	264,8	371,8	73%	84%
Atlantic	59,0	39,7	24,8	5%	-58%
Mediterranean	49,3	59,0	98,7	19%	100%
Total public investment	327,0	379,0	507,6	100%	55%

Source: EC WORKING PAPER ON PUBLIC FINANCING AND CHARGING PRACTICES IN THE COMMUNITY SEA PORT SECTOR, 1998

Table 3.5: Public investment in port superstructure and services

Maritime Region	1995 (Mio. Euro)	1996 (Mio. Euro)	1997 (Mio. Euro)	Regional split (1997)	Evolution 1995-1997
Baltic	161,9	163,6	224,8	34%	39%
North Sea	329,9	369,4	353,6	53%	7%
Atlantic	13,0	7,7	17,8	3%	36%
Mediterranean	66,9	68,0	67,5	10%	1%
Total public investment	571,7	608,7	663,6	100%	16%

Source: EC WORKING PAPER ON PUBLIC FINANCING AND CHARGING PRACTICES IN THE COMMUNITY SEA PORT SECTOR, 1998

Table 3.6: Public investment in maintenance and other activities

Maritime Region	1995 (Mio. Euro)	1996 (Mio. Euro)	1997 (Mio. Euro)	Regional split (1997)	Evolution 1995-1997
Baltic	33,6	30,7	31,1	12%	-8%
North Sea	146,8	201,3	197,0	77%	34%
Atlantic	6,3	6,6	10,3	4%	64%
Mediterranean	21,2	15,7	16,4	6%	-23%
Total public investment	207,8	254,3	254,8	100%	23%

Source: EC WORKING PAPER ON PUBLIC FINANCING AND CHARGING PRACTICES IN THE COMMUNITY SEA PORT SECTOR, 1998

In order to assess the above data on public investment in ports by Community maritime region public investments need to be set against traffic handled by ports in the individual maritime regions.

Table 3.7: Freight turnover in major Community ports (1993-1996; Mio tones)

Maritime Region	1995	1996	1997	Regional	Evolution

	(Mio. Euro)	(Mio. Euro)	(Mio. Euro)	**split (1997)**	Euro/ton 1996
Baltic	211,9	234,3	9%	11%	0,93
North Sea	1206,1	1.282,8	49%	6%	0,72
Atlantic	378,6	399,4	15%	55	0,16
Mediterranean	675,7	705,3	27%	4%	0,26
Total public investment	2.472,3	2.621,8	100%	6%	0,53

Source: EC WORKING PAPER ON PUBLIC FINANCING AND CHARGING PRACTICES IN THE COMMUNITY SEA PORT SECTOR, 1998

In the **North Sea** region, covering with major ports some 50% of the European port traffic, public financing, in absolute terms, is the highest in comparison to other Community regions. Noteworthy is also the high level of public investments in this region in relation to traffic per ton. This may indicate, on the one hand, the enormous financing needed to remain state-of-the-art, but also, on the other hand, be an indicator for substantial capacity build-up through modernization and/or expansion of existing infrastructure with the help of public funds. The latter conjecture is supported by the fact that public investments, particularly in port infrastructure and maintenance, are showing one of the highest growth rates in comparison to other Community maritime regions.

Data on public financing, as available from Member States replies, shows a different picture for the **Baltic** region. Here clearly the emergence of new markets is reflected in the boom for typical 'start-up' investments in ports such as land purchase, basic maritime access and infrastructure links. The same can be said for public support in more commercially oriented investments like superstructure and services, whereas, for obvious reasons, spending on maintenance is less prominent. Considering the relatively small share of overall Community port traffic, public funds play an important role in creating an operational port sector in this region.

The share of total public spending in Atlantic ports is, in absolute terms and over time, one of the lowest in the Community. Indeed, overall public investments in these ports seem to indicate a trend, which is contrary to a steady growth in traffic. However, a clear orientation towards commercialization and increase in port efficiency is indicated in the dynamic evolution of public support, albeit on low absolute levels, for investments in superstructure, services and maintenance.

Data on Mediterranean ports

In the following tables the main ports of Mediterranean Sea are presented. According to Drewry Shipping Consultants, total container traffic in the Mediterranean reached 19 million TEUs in 1998. Of the region's total port capacity of 30 million TEUs, privately owned container terminals and ports held roughly 51% in 1998. That total is expected to climb to 53 million TEUs by 2015.

Traffic at gateway ports, now representing about 67% of the total, is expected to drop to 55% of the total by 2015, as transshipment volumes grow. Part of the reason for the optimistic forecast of growth in the region's ports is the contribution expected from private investors, who bring know-how and efficient practices along with investment. The **Mediterranean** is experiencing high growth rates for public investments in port infrastructure, indicating considerable increases in capacity and/or efficiency within existing ports. On the other hand, decreasing public financing for typical 'start-up'

investments (however on substantial level) seem to indicate that in this region capacities have been progressively adapted to demand.

Table 3.8: Sea Container Port Traffic (in TEU) for EU Mediterranean Ports

Port	**Container port traffic (1000 TEU)**		
	1997	**1998**	**Change 98/97 (%)**
Gioia Tauro	1449	2126	+46.7
Algeciras	1703	1812	+6.4
Genoa	1180	1266	+7.3
Barcelona	972	1095	+12.7
La Spezia	616	732	+18.8
Piraeus	684	933	+36.4
Marseille	622	660	+6.2
Limassol	237	213	-10.1
Malta (Marsaxlokk)	662	1071	+61.7
Valencia	832	1005	+20.7
Totals	**8957**	**10913**	**+21,8**

Source: Official Port Statistics

Table 3.9: Sea Container Port Traffic (in tones) for EU Mediterranean ports

Port	**Container port traffic (million tones)**		
	1997	**1998**	**Change 98/97 (%)**
Marseille	94,3	93,4	-0,9
Trieste	46,4	47,2	+1,7
Genoa	45,9	45,9	+0,0
Algeciras	37,3	42,1	+12,9
Piraeus	14,9	19,8	+24,7
Thessaloniki	13,4	13,7	+2,4
Limassol	3,2	2,9	-9,3
Valencia	17,9	20,2	+12,8
La Spezia	10,7	13,8	+28,9
Barcelona	25,6	26,1	+1,9

Totals	**309,6**	**325,1**	**+5,0**

Source: Official Port Statistics

Tables 3.10 and 3.11 present the main port infrastructure cost items and the EU port infrastructure cost per category item for the Mediterranean ports.

Table 3.10: Port Infrastructure Cost Items

Maritime access	▪ Capital dredging ▪ Sea locks, dam & exterior breakwaters ▪ VTS / Radar & ship movement information networks ▪ Lights buoys & navigational aids
Port infrastructure	▪ Land reclamation works ▪ Internal locks (new work & capital repairs) ▪ Docks, quays (quay walls), jetties piers, berths, river berth & harbor basin dredging
Port superstructure	▪ Pavements ▪ Warehouses; sheds ▪ Cranes and gantries and other mobile / semi-mobile ▪ equipment ▪ Linkspans ▪ Terminal and office buildings and other associated facilities; ▪ Leasing / renting of buildings and / or equipment ▪ Public utilities (sewage, water supply etc.)
Infrastructure links	▪ Railways & metro links within the port area ▪ Roads within the port area ▪ Canals within the port area ▪ Tunnels and bridges within the port area
Port maintenance works	▪ Maintenance dredging ▪ Maintenance of port infrastructure and superstructure ▪ Others
Port services	▪ Cargo handling (stevedoring, storage, stowage) ▪ Technical-nautical services (pilotage, towage, mooring) ▪ Other services (fire fighting, water & electricity supply, safety services, bunker age, cleaning, pollution control etc.)
Other port activities	▪ Promoting industrial areas or units, port-related activities such as added-value enterprises etc.

Source: IMO

Table 3.11: The Mediterranean port infrastructure cost per category item

Cost Category	1995 (Mio. Euro)	1996 (Mio. Euro)	1997 (Mio. Euro	Split per category (1997)	Evolution 1995-1997
1.1 – Land purchase	6,699	5,148	15,68	4%	139%
1.2 – Maritime Infrastructure &Access	24,8787	25,74	17,64	5%	-28%
1.3 – Port infrastructure	49,05	59	98,7	32%	55%
1.4 – Port superstructure	38,194	31,28	36,45	22%	6%
1.5 – Infrastructure links	10,5105	12,012	5,88	2%	-47%
1.6 – Port maintenance	17,2482	13,031	14,104	14%	30%
1.7 – Port services	26,4081	36,72	31,05	19%	31%
1.8 – Other port activities	3,8964	2,669	2,296	2%	-7%
Total Cost	176,8849	185,6	221,8	100%	24%

(Based on Source: EC WORKING PAPER ON PUBLIC FINANCING AND CHARGING PRACTICES IN THE COMMUNITY SEA PORT SECTOR, 1998)

The latter table was constructed using tables 3.1 to 3.6. In table 3.1 data on investment financing for the whole EU were available. In tables 3.2 to 3.6 data on investment financing for the Mediterranean for each cost category were available. So table 3.11 is analogous to 3.1 based on the data of tables 3.2 to 3.6.

3.1.2. Short Sea Shipping in Greece and the Role of Ports

Short-sea shipping in Greece has experienced a significant transformation in the last 20-30 years, and is likely to experience another one in the years ahead (therefore it is rather possible to observe strange relationships between costs/revenues and traffic volumes). The first such transformation concerned the gradual substitution of mixed passenger/car ferry vessels for the more traditional passenger-only vessels sailing in the Aegean and Ionian seas. The second transformation concerns the potential role of fast vessels of new design, whose appearance in the system has already started[6].

According to the Greek legislation and the Code of Maritime Law Short-sea shipping can be thought as coinciding with Coastal shipping given the particularities of the Greek maritime space (numerous islands being close to each other). According to the Greek literature[7], the focus of domestic SSS is on the transfer of passengers and cargo between Greek ports, which is reserved exclusively for ships flying the Greek flag. The right to transfer passengers between Greek ports belongs exclusively to liner Greek passenger ships. Direct transfer of passengers between Greek and foreign ports and vice-versa can also be executed by foreign-flag passenger ships, on the basis of reciprocity.[8]

The right to carry cargo between Greek ports belongs exclusively to Greek cargo ships of up to 1000 GRT.

Greece has recognized the critical importance that the development of the ports has on short-sea shipping. This can be thought as referring to the ports' infrastructure, either in terms of facilities or in terms of services, because ports provide the interoperability and create new meeting points with the other modes. The major part of the realized, or planned, investments in ports and port-related infrastructures aim to enhance their efficiency and to facilitate the integration of short-sea shipping with the Trans-European multimodal transport network of the future.[9] In general port infrastructure development has the potential to offer:

- Access to the European Union, including the connection of the Trans-European transport network with the non-EU and many non-European countries;

- Connection services between different parts of the transport network, including those

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[6] H.Psaraftis, A. Papanikolaou, *"Impact of new technologies on short sea shipping in Greece"*

[7] Psaraftis H.N. *"Greek Coastal Shipping: Status, Prospects and Investment Opportunities"*, Final Report to ETBA (in Greek), December 1993.

[8] S.G. Sturmey, G. Panagakos, H.N. Psaraftis, *"Institutional and socio-economic issues in Greek ferry services"*

[9] C.I. Chlomoudis and A.A. Pallis, "Investment Policies in Ports' Infrastructure in the perspective of the European Short sea shipping networks: The case of Greece".

which are the most environmental friendly

- A significant contribution to the concept of the sustainable mobility, especially in the cases that the sea leg of the transportation process is the main part of the journey.

To satisfy the continuous growth of this demand, major infrastructure improvements are essential. Moreover, administrative and operating changes are necessary. They would facilitate the maximization of the benefits from the present and the future infrastructure. Consequently, Greek ports would serve efficiently the demands for modernized and reliable short-sea shipping services, contributing in this way to the more balanced distribution of the traffic within the single market. This policy implicates significant volumes of investments.

3.1.3. Port of Piraeus

Piraeus is the largest passenger port in the Mediterranean Sea serving about 7 million passengers per year. It is also major commercial port with a variety of cargoes (general cargo, container traffic etc). Moreover, it shows growing transshipment container traffic. Construction works are currently in progress concerning the improvement of passenger port, as well as the extension of the container berths and the yards in the commercial port.

Today, the port of Piraeus is an International Center of transit and regional trade, with an annual container throughput of 1.000.000 TEU (Twenty-foot Equivalent Unit is the unit of measurement of container traffic, and refers to the standard 20-foot container).

Piraeus is the first container handling port in Eastern Mediterranean. In the near future, Piraeus is expected to reinforce its position even more and become an International Hub. For this purpose, a railway connection to the port has been scheduled. The Piraeus Port Authority (PPA) is responsible for the port administration. The total number of PPA personnel (including about 700 dockworkers) is about 2,100. The Authority is broken down into 12 departments and four minor divisions, all reporting to the Managing Director. PPA has been operating as a corporation, gaining the power to play a significant role in the international developments in the area of sea borne trade and means of transport.[10] The financial support for infrastructure works is estimated up to 12 billion GRD (35.3 million EURO).

According to the Law 1699/1999 the PPA transformed into Corporation (Societe Anonym). The aim of the Corporation is the administration and exploitation of the port and particular:

- The provision of berthing facilities and the handling of cargoes and passengers, to from the port
- The installation, organization and exploitation of every kind of port related infrastructure

[10] Harilaos Psaraftis, Managing Director PPA, 1999

– The undertaking of any activity connected with port related projects as well as any other form of commercial, industrial oil related and enterprising activity, including especially tourist, cultural and fishing activities, as well as the planning and organization of port facilities.

The Port of Piraeus consists of two major areas: the Inner Port (Central Port), which serves mainly passenger traffic and the Commercial Port at Ikonion which serves exclusively the container and general cargo trade.

The Piraeus Central Port has a total water surface area of 1.100.000sq.m. and is divided into three basins:

- the main port in the center with a water surface area of 530.000sq.m.,
- the outer port (know also as Lion Port) with a water surface of 430.000sq.m., and
- Along Port on the north east side with a water surface area of 140.000sq.m. The natural depth reaches 27 meters, while depths alongside range from 6 to 16 meters.

The Commercial Port at Ikonion, is located two miles northwest of the Central Port of Piraeus and it is known as the Hercules Port, Container Terminal. Having a water surface area of 640.000 sq.m., this port handles coal and metallic ores, freight carried to and from domestic Greek Ports in small cargo motor ships and the total movement of containerized freight.

The port statistical department has provided the following table 3.12 including all the statistical data for the commercial port activities. According to the data provide the port of Piraeus has a 5% of total freight traffic in the Mediterranean Sea.

Table 3.12: Piraeus port statistical data

	Commerce activity at the main port (in mio tons)			
Cargo category	1998	1997	Differences	Evolution (%)
A. International				
1. Unloading	5.920	4.434	1.485	33,50%
2. Loading	3.315	2.347	968	41,25%
TOTAL of works abroad	*9.235*	*6.781*	*2.453*	*36,18%*
B. Domestic				
1. Unloading	1.100	1.038	58	5,63%
2. Loadings	1.388	1.303	85	6,58%
TOTAL of works inland	*2.485*	*2.341*	*144*	*6,16%*
GRANT TOTAL	**11.720**	**9.122**	**2.597**	**28,48%**

Source: Piraeus Port Balance Sheets

	Containers' distribution							
	1998			1997			Differences	
	TEUS	TONS	Percentage over the total tons	TEUS	TONS	Percentage over the total tons	TEUS (%)	TONS (%)
Unloadings								
1. Import	260.918	2.874.425	35%	242.461	2.666.203	46%	7,61%	7,81%
2. Transshipment	1.811.668	2.136.173	26%	85.397	1.014.887	17%	112,73%	110,48%
TOTAL	*2.072.586*	*5.010.598*	*61%*	*327.858*	*3.681.090*	*63%*	*34,99%*	*36,12*
Loadings								
1. Export	87.048	992.686	12%	90.519	1.070.036	18%	-3,83%	-7,23%
2. Transshipment	184.474	2.170.781	27%	84.792	1.067.661	18%	117,56%	103,32%
TOTAL	*271.522*	*3.163.467*	*39%*	*175.311*	*2.137.697*	*37%*	*54,88%*	*47,98%*
Fraught	714.108	8.174.065	100%	503.169	5.818.787	100%	41,92%	40,48%
Empty	218.988	0		180.800	0		21,12%	
GRANT TOTAL	**933.096**	**8.174.065**		**683.969**	**5.818.787**		**36,42%**	**40,48%**

Source: Piraeus Port Balance Sheets

3.1.4. Infrastructure Costs and Benefits for Piraeus Port

The financial results of the PPA for the years 1994-1998 are presented in the following table 3.13

Table 3.13: Financial results (Revenues, Expenses, Investments) in million EURO

	1994	**1995**	**1996**	**1997**	**1998**
Revenues	77,0066	91,60675	95,46588	94,77623	122,6853
Expenses	67,7036	74,21864	84,10858	87,45415	95,05503
Revenues/Expenses ratio	88%	81%	88%	92%	76%
Investments	19,75055	25,23844	29,88995	24,68085	17,46148

Source: Piraeus Port Authority Balance Sheet, 1998

Revenues in that budget are generated from cargo handling, port dues, storage and generally any charge to port users for services rendered to them. Expenditures are related to salaries of PPA personnel, construction and maintenance of port infrastructure, purchase of equipment, and other port operating expenses.

The revenues/expenses relation is quite high up to 80%. Unfortunately for year 1998 this relation is lower than the previous years. But there is an increase of revenues up to 30% for 1998 in relation with 1997 results. According to this results the income (revenues) mix reflects to a public management model with high management autonomy and a port operating company operation in a mixed holding between public and private operators. The highest income % becomes from cargo charging activities (56%). There are also other income activities like cargo handling, vessels charging, renting, and other revenues with shorter % (5%-15%).

The rate of investment/transport volume in Mediterranean region in 1996 was 0,26 Euro/ton according to table 3.7. The relevant rate for Piraeus port for 1998 is 0,88 Euro/ton, which is comparable with North Sea ports figures.

According to the balance sheet of the PPA and the economic results for the year 1998 it is observed the following indexes for Piraeus Port Authority.

Table 3.14 Financial indexes for PPA

	DRS	EURO
Cost per ton	1131	3,32
Cost per ship visit	891633	2616,68
Average charge per TEU	19801	58,11
Revenue from TEU (millions)	18476	54,22
Total Revenue (millions)	57340	168,28
Port revenue per employee	27.304.762	80131,36

Source: SYSTEMA Consulting S.A.

All these indexes in comparison with the international bibliography[11] and selected references as presented above are showing that PPA is charging less that the other international ports, having an acceptable cost per mass ton and rather low cost per ship visit.

The following cost categories are reported in the official balance sheets of PPA for the years 1997 and 1998.

Table 3.15: PPA cost categories in million EURO

	Cost categories	*1998*	*1997*	*% Evolution*
L1	Administration	26,44167	23,30007	13,5%
L2	Employees	1,021277	1,198826	-14,8%
L3	Technicians	3,025679	2,808511	7,7%
L4	Workers	25,60382	25,88408	-1,1%
L5	Burge workers	0,927366	1,138665	-18,6%
L6	Operations	4,454879	4,68672	-4,9%
L7	Maintenance	1,60088	1,775495	-9,8%
L8	Supplies	3,187087	2,705796	17,8%
L9	Equipment	5,531915	11,60382	
L10	Roads	5,672781	4,290536	
L11	Buildings	2,497432	0,971387	
L12	Port works	3,512839	4,595745	

Source: Piraeus Port Authority Balance Sheet, 1998

The following table summarizes the total traffic in Piraeus Port.

[11] Industry Commission, "Port Authority services and activities", Australian Government Publishing Service, 1993

Table 3.16: Traffic data for Piraeus Port (1997-1998)

Categories	1998	1997
Passengers		
Domestic Passengers	565483	537130
International Passengers	8364688	7407129
Total passengers	8930171	7944259
Freight		
TEUs	933096	683969
Tons	8174065	5818787
Goods Traffic (M tons) Unloading	7016911	5473002
Goods Traffic (M tons) Loading	4703554	3649740
Total Freight	19894530	14941529
Ships	28348	

Source: Official Port Statistics

After the identification of main infrastructure elements (Table 3.10), main costs (Table 3.15) and outputs (Table 3.16) the investigation on the existence of short-run marginal cost per activity comes next. Given that only particular components of costs vary with usage, as already presented in paragraph 2.1 it is important to identify which components vary and how in order to identify the short run marginal infrastructure cost components.

3.2. Variability in the Short-Run Vs Long-Run

Although there is a whole range of marginal costs, depending on how far ahead one looks, economic theory usually distinguishes between short-run and long-run costs in the following way: short-run refers to costs associated with the use of existing capital assets; long-run covers their existing use as well as their eventual replacement or maintenance. Short-run costs, therefore, correspond to immediate escapable or enforceable costs (where immediate may represent a period of several months), while long run costs correspond to ultimately escapable or enforceable costs.

Therefore a rough assumption is that, in the long run analyses, all costs are assumed to be variable. There are no fixed factors of production, the costs of which had to be met regardless of whether the production level. In the long run, all factors of production are variable and all costs are escapable. The short run, by contrast, is a period during which at least one factor of production is fixed. In the usual analysis the assumption is that the capital is fixed. Therefore, the only way that the output can be affected is through other changes (maintenance, labor, operation etc.).

The main item for short-run marginal cost is always maintenance. Replacement usually occurs cyclically but belongs also to the use of the existing assets, therefore also falls within the short-run marginal costs. In addition, operation and labour costs fall into the short-run marginal cost. The latter (labour) is a tricky one; it is clear that temporary staff has to do with short –run marginal costs, but there is a question whether there are also adjustments over time of permanent employees if business is changing. Regarding administration staff, previous literature makes clear that can vary only in the long run. Regarding the rest of the permanent employees (workers, technicians), one would need to look on a time series basis of employees and traffic

volume (although decreasing employment has obviously also to do with productivity gains), if time series data are available.

It is obvious, from the above, that in the long run more costs are immediately escapable. Therefore, a basic consequence of a short run cost estimation is a lower value of the marginal cost. The later is fostered also from the current point in the operating cycle; the short-run costs do not rise continuously as the time horizon increases but they rise irregularly as more and more escapable costs come up for review. Thus, the value of the short-run marginal cost depends also on the current point of time[12].

3.3. Cost Variability and Estimates of Short-Run Marginal Cost

3.3.1. General Considerations

Based on the above, regarding infrastructure cost categories for a port that could be relevant for short run marginal costs, the ones that vary with the volume of output in the short run (and be also relevant to infrastructure) are:

- Temporary Personnel and Seasonally Permanent Personnel (Technicians, Workers), including overtime
- Maintenance of Port Infrastructure – i.e. Dredging
- Supplies for Port Infrastructure and Maintenance
- Port Services - i.e. SOLAS provisions-environment
- Maritime Access – i.e. Navigational means
- Infrastructure Links – i.e. Traffic management

3.3.2. Application for the Port of Piraeus

Please note that for Piraeus Port, according to table 3.16, data only for the first three cost categories are available, i.e.:

- Temporary Personnel (Technicians, Workers) – *parts of L3, L4*
- Maintenance of Port Infrastructure – i.e. Dredging – *a part of L7*
- Supplies for Port Infrastructure – *L8*

As it concerns Administration and Employees for the Port of Piraeus (L1, L2), they can vary especially by changes in passenger traffic but only in the long run.

Finally, Operation (L6) is not relevant to infrastructure and Equipment, Roads, Buildings and Other Port Works (L9, …L12) are considered as fixed capital costs, according to UNITE directions.

[12] Heggie, I.G., 1972, Transport Engineering Economics, McGraw-Hill

According to the official balance sheets of PPA for the years 1997 and 1998 for the three cost categories mentioned above, the following analytical data exist:

Table 3.17: Infrastructure Relevant Cost Variability with Traffic Volume (mio EURO) for Piraeus Port

	Cost category	Cost Sub-Categories	1998	1997	Change
L3	**Technicians**	Permanent	0,062	0,050	18,1%
		Temporary (operations)	2,964	2,759	7,5%
		Total	3,026	2,809	**7,7%**
L4	**Workers**	Permanent	25,604	25,884	-1,1%
		Temporary	*0,000*	*0,000*	*0%*
		Total	25,604	25,88	**-1,1%**
L7	**Maintenance**	Tag boats-pilotage	0,015	0,056	-73,4%
		Buildings & Port Works	*0,022*	*0,006*	*302,7%*
		Equipments	0,335	0,337	0,7%
		Cleaning services	1,209	1,371	11,8%
		Port Infrastructure (Dredging)	*0,021*	*0,006*	*251,5%*
		Total	1,601	1,775	**-9,8%**
L8	**Supplies**	*Infrastructure & Maintenance*	*3,187*	*2,706*	*17,8%*
		Total	0,062	0,050	**17,8%**

According to the above table the costs relevant to infrastructure that vary with traffic volume in short run are in italics. Consequently these are the costs that contribute to the short run marginal port infrastructure cost.

3.4. Method for Estimating Marginal Infrastructure Costs

3.4.1. Engineering approach for Mediterranean SSS

For each item (or sub-items) define in the previous paragraph 3.3 as infrastructure costs the economic values for post services, port maintenance and other administrative activities will be validated, using linear equation define value for 1998. Then contribution to MC calculations = Ø.

A consideration of maintenance and operational cost items occurring every year, then put value of 1998. Items occurring periodically (e.g. every X years) then compute the average per year on the basis of costs before 1998 and for the base year 1998 and the period after it. Compute the relevant traffic of activities for the whole X years period and take the average.

Cost Allocation

- Allocation of labor costs (temporary, on contract basis) for each activity: $\mathbf{Cl_a}$
- Allocation of maintenance and other operating costs for each activity: $\mathbf{Cm_a}$ (with the note for case of X years)
- Allocation of infrastructure costs (services, superstructure) for each item and each activity: $\mathbf{CI_{i,a}}$

Where:

a =(1,…,n) , n=2 (Activities for Freight Transport, Activities for Passenger Transport)

Cost analysis

☛ **Compute the difference between year y (e.g. 1997) and 1998 of the infrastructure costs per activity a**

$\mathbf{DC}_{1997,1998} = [\Sigma_{i=1}CI_{i,a} + CLa + CMa]_{1997}$

$[\Sigma_{i=1}CI_{i,a} + CLa + CMa]$

☛ **Compute the difference in volumes**

$DV_{1997,1998} = V_a - V_a$

Then $\mathbf{MC_{1998}} = \mathbf{DC}_{1997,1998} / \mathbf{DV}_{1997,1998}$ ***Engineering approach for Piraeus Port***

For the case of Piraeus port, the marginal cost of capacity (MCC) would be the additional cost of infrastructure required to attend one more unit above the maximum installed port's capacity. The idea of long-run marginal cost is that if users pay that price for the use of the port, the port authority would be able not only to cover the operating costs, but also to finance the infrastructure construction costs. Therefore, the problem posed above by the short-run marginal cost pricing rule would be solved.

For each item and the sub-items defined in the previous paragraphs and tables as PPA infrastructure cost categories (table 3.16) all the economic values of the assets will be validated for the years 1997 and 1998. For each item (or sub-items) define in the previous paragraph 3.3 as infrastructure costs the economic values for post services, port maintenance and other administrative activities will be validated, using linear equation define value for 1998. Then contribution to MC calculations = Ø.

The consideration of infrastructure related maintenance, administration and operational cost items occurring every year then put value of 1998. Compute the relevant traffic of activities for the whole X years period and take the average.

Cost Allocation

- Allocation of labor costs as described in cost categories L3, L4 (temporary, on contract basis) for each port activity: $\mathbf{Cl_a}$
- Allocation of maintenance L7 and other operating costs for each port activity: $\mathbf{Cm_a}$ (with the note for case of X years)

- Allocation of infrastructure costs (services, supplies) L8 for each item and each activity: $\mathbf{CI_{i,a}}$

Where :

a =(1,…,n) , n=2 (Activities for Freight Transport, Activities for Passenger Transport)

A consideration of maintenance and operational cost items occurring every year then put value of 1998. Items occurring periodically (e.g. every X years) then compute the average per year on the basis of costs before 1998 and for the base year 1998 and the period after it. Compute the relevant traffic of activities for the whole X years period and take the average

Cost analysis

☞ **Compute the difference between year y (e.g. 1997) and 1998 of the infrastructure costs per activity**

$DC_{1997,1998} = [\Sigma_{i=1}CI_{i,a} + CLa + CMa]_{1997} -$

$[\Sigma_{i=1}CI_{i,a} + CLa + CMa]$

☞ **Compute the difference in volumes**

$DV_{1997,1998} = V_a - V_a$

Then $\mathbf{MC_{1998}= DC_{1997,1998} /DV_{1997,1998}}$

3.5. Alternative Approach (Econometric Approach)

As discussed earlier due to the complex structure of ports economy the estimation of total a statistical relationship between activities and cost drivers in ports is rather difficult. Even the derivation of individual cost functions per activity proved to be hard due to data limitations. Nevertheless, an econometric model for the estimation of port activities cost function took place, although its operation was not possible.

Following the UNITE general principles of the econometric approach the model formed is the translog-function next:

$$\ln C_i = a_0 + \sum_{j=1}^{m} a_{ij} \ln Y_{ij} + \sum_{j=1}^{m} b_{ij} W_{ij} + \sum_{j=1}^{m} c_{ij} S_{ij} + \sum_{k=1}^{r} d_{ik} I_{ik} + \sum_{l=1}^{s} e_{il} Z_{il}$$

$$+ 1/2 (\sum_{k=1}^{m} \sum_{p=1}^{m} f_{ijp} \ln Y_{ij} \ln Y_{ip} + \sum_{j=1}^{m} \sum_{p=1}^{m} g_{ijp} \ln W_{ij} \ln W_{ip} + \sum_{j=1}^{m} \sum_{p=1}^{m} h_{ijp} \ln S_{ij} \ln S_{ip} + \sum_{k=1}^{r} \sum_{u=1}^{r} k_{iku} \ln I_{ik} \ln I_{iu}$$

$$+ \sum_{l}^{s} \sum_{z}^{s} l_{ilz} \ln Z_{il} \ln Z_{iz}) + \sum_{j=1}^{m} \sum_{p=1}^{m} m_{ijp} \ln Y_{ij} \ln W_{ip} + \sum_{j=1}^{m} \sum_{p=1}^{m} n_{ijp} \ln Y_{ij} \ln S_{ip} + \sum_{j=1}^{m} \sum_{k=1}^{r} o_{ijk} \ln Y_{ij} \ln I_{ik}$$

$$+ \sum_{j=1}^{m} \sum_{l=1}^{s} p_{ij} \ln Y_{ij} \ln Z_{il} + \sum_{j=1}^{m} \sum_{p=1}^{m} q_{ijp} \ln W_{ij} \ln S_{ip} + \sum_{j=1}^{m} \sum_{k=1}^{r} r_{ijk} \ln W_{ij} \ln I_{ik} + \sum_{j=1}^{m} \sum_{l=1}^{s} s_{ijl} \ln W_{ij} \ln Z_{il}$$

$$+ \sum_{j=1}^{m} \sum_{k=1}^{r} u_{ijk} \ln S_{ij} \ln I_{ik} + \sum_{j=1}^{m} \sum_{l=1}^{s} v_{ijl} \ln S_{ij} \ln Z_{il} + \sum_{k=1}^{r} \sum_{l=1}^{s} w_{ikl} \ln I_{ik} Z_{il})$$

With:

i : index for port sections (i=1,…,n)

j : index for vessels categories (j=1,…,m)

k : index for type of infrastructure characteristics such as basins, etc (k=1,…,r)

l : index for type of climate and weather factors such as wind etc.

(l=1,…,s)

C : Port Relevant Infrastructure Costs

Y : Volumes

W: Vessel size

S : Vessel speed

I : Infrastructure characteristics

Z : Climate and weather factors

For obvious reasons this full translog-function has in a next step to be reduced. For example it is not very possible that there are significant relationships between the number of basins and the weather conditions or, we could even face the problem that the data analysis could result pseudo-correlations or even non-sense correlations. This reduction could therefore be done by theoretical considerations for the existing or no-existing relationships among the variables and by statistical hypothesis testing. In any case it is not possible this to be done in this case study due to data limitations meaning most of the data needed to define the above variables do not exist.

4. Results

Based on the methodology presented in part 3.4, the obtained results from its application for Piraeus Port, regarding freight transport are:

Table 4.1: Piraeus Port Short-Run Marginal Infrastructure Cost (Freight)

			1998	**1997**
Cost Category (mio EURO)	Temporary Personnel	$\mathbf{Cl_a}$	0	0
	Maintenance of Port Infrastructure	$\mathbf{Cm_a}$	0,043	0,012
	Supplies for Port Infrastructure and Maintenance	$\mathbf{CI_{i,a}}$	3,187	2,706
Volumes	TEUs		933096	683969
$\mathbf{SRMC_{1998}} = \mathbf{DC}_{1997,1998} / \mathbf{DV}_{1997,1998}$ $\mathbf{DC}_{1997,1998} = [\Sigma_{i=1} CI_{i,a} + CLa + CMa]_{1998} - [\Sigma_{i=1} CI_{i,a} + CLa + CMa]_{1997} = [(0+0{,}043+3{,}187) - (0+0{,}012+2{,}706)]$ $\mathbf{DV}_{1997,1998} = V_{a,1998} - V_{a,1997} = 933096-683969$				
SRMC	**EURO/TEU**			
	2,06			

We observe rather low marginal cost, which can be explained from four factors:

- The low variable cost due to certain assumption in the UNITE framework and the short-run estimation (instead of a long-run)
- The high volume change that corresponds to low variable costs.
- The lack of extensive time series data with the same accounting principles that forced the use of only two years data.
- Possibly on the nature of data; for these two specific years that present “negative investments”.

5. Generalization and Transferability of Results

The methodological approaches to SSS infrastructure costing proposed for Mediterranean Sea, described in section 2 and 3 and applied in section 4 for the Port of Piraeus have the potential to be used for SSS in other EU countries and regions. However, the approaches, as means of deriving estimates of the full price-relevant marginal social costs of infrastructure use, would benefit from some modifications, most notably to include full infrastructure costs.

Due to the limited data for the rest of Mediterranean ports (tables 3.1,.., 3.11) a rough estimation of the SRMC for the whole Mediterranean was calculated, which probably needs to be validated from the relevant port authorities.

The methodology was presented in 3.4.1 and it is similar with methodology presented in 3.4.2 for Piraeus. But certain assumptions had to be made since official and analytical balance sheets from all the Mediterranean ports were not available. From tables 3.7, 3.8 and 3.9 the volumes in TEUs and tons were available for

Mediterranean for the years 1996 – 1997. In addition, the relevant costs were summarized in table 3.11 for the same years.

So, to calculate the SRMC, we applied the same principles with those of SRMC for Piraeus Port.

The results are presented next in Table 5.1.

Table 5.1: Total SRMC in Mediterranean SSS (Freight),(mio EURO)

			1997	**1996**
Costs (Total)	Temporary Labor	**Cl_a**	0	0
	Port Maintenance Works	**Cm_a**	22,3482	21,5322
	Port Services, Infrastructure Links, Maritime Access	**$CI_{i,a}$**	41,34	55,167
Volumes (Total)	TEUs		25800000	58775000
$SRMC_{1998}$= $DC_{1997,1998}$ /$DV_{1997,1998}$ **$DC_{1997,1998}$ = [$\Sigma_{i=1}CI_{i,a}$ + CLa + CMa]$_{1997}$ – [$\Sigma_{i=1}CI_{i,a}$ + CLa + CMa] =[(0+22,3482+41,34) – (0+21,5322+55,167)]** **$DV_{1997,1998}$ = V_a - V_a= 25800000 – 58775000**				
SRMC	**EURO/TEU**			
	0,39			

It is obvious – as in Piraeus case – that the use of only two years data is mainly responsible for the low value of SRMC.

6. Conclusions

Tables 4.1, 5.1 have highlighted the results, for the short run marginal cost expressed in EURO/TEU. Some concluding remarks are:

- Short-Run Marginal Costs in general are very low; due to:

- specific assumptions for the application of short-run principles that lead to inclusion in the calculation of SRMC of few costs elements

- out of the costs elements eligible for the inclusion in the SRMC, some were not included due to lack of data or non-existence (i.e. during the years considered no such costs were taken place)

- the volume changes were high, and thus the obtained result is even lower.

- the limited number of used years due to lack of available data, have contributed – possibly- to this low value of short run marginal cost.

- possibly the nature of data, i.e. the specific years under consideration in the operating cycle of a port

- The result for the whole Mediterranean area, excluding Piraeus, is rough estimation, and need probably validation from the relevant authorities, due to data limitations (although data were requested, still we have not received anything from the relevant port authorities).

Further concluding remarks –not conclusions - deal with the ability of pricing in ports based on marginal cost, and especially the short-run marginal cost, since one of the objectives of this case study is the possible investigation of how relevant the tariff policy or else port pricing policy of SSS services is related to the marginal costs. Detailed investigation has not taken place since it is not necessary in the UNITE framework, but some literature review and theoretical analysis showed that there is no specific correlation between port tariffs and port marginal cost.

While earlier pricing literature advocated marginal cost pricing as an appropriate pricing policy, more recent literature highlights its shortcomings. To ensure the economic viability of a port, pricing should be based on the long run costs and not on *"the economist's short run pricing principles"* (Bromwich, 1978, p.228)[13]. Finally, more recently, Talley (1994)[14] states that *"in attempting to apply marginal cost pricing to ports, a practical problem arises – the inability of ports to determine the marginal costs of their services"*.

The latter quoted remark by Talley, leads to the basic conclusion of this case study: It is rather difficult to develop a specific methodology for the estimation of the short run (or any other i.e. long run) marginal cost for port services thus also for port infrastructure. In any case, the role of this case study was not to develop such a methodology but by using practical experience estimate the short run marginal infrastructure cost of Mediterranean ports including Piraeus. The practical-engineering approach developed in this study for this estimation (under the absence of time series data and generally sufficient data), could probably give "better" results if sufficient data were available.

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