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A NEW GENERATION OF CONTAINERSHIPS: CAUSE OR EFFECT OF THE ECONOMIC DEVELOPMENT?

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SUMMARY

For years, and more and more insistently, globalization of economy and world trade is a common concept which is in all communications media. Nevertheless, freight market and shipbuilding have been traditionally globalized markets. Does it mean that nothing has happened to these sectors? Of course, not. The globalization of the world trade has had and is having a crucial effect on shipping and shipbuilding, as it can be seen in the growing sizes of the vessels used in the transport.

The development of the international trade and its extension to a world scale has determined an important and generalized change in the industrial structures and in the distribution of products. In particular, the generalization of the containerisation of the general cargo has developed an efficient and economic transport that has allowed its multiplication and, as a consequence, the delocalisation of numerous industries.

Some changes have been determinant in this sense:

- **The shifting of carriers' strategy from a port to port procedure to a door to door system.**
- **The generalisation of intermodalism.**
- **The progressive containerisation of commodities traditionally carried as bulk cargoes.**
- **The economies of scale.**
- **The maintenance and even the reduction of freight rates.**

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All these characteristics imply the worldwide movement of a huge number of commodities (raw materials, parts, semi-finished products, etc.) which have to be brought together and assembled wherever is cheapest, as a consequence of the globalization of production facilities.

In this paper, the most important effects of this apparently uncontrollable unstoppable change will be analysed, as well as its main consequences on shipping and the size of the ships.

INTRODUCTION

After the United Nations were founded in 1945, the states tried to establish a new relationship model between the nations based on the international commerce, and so the International Monetary Fund (IMF) and the World Bank (WB) were created, and afterwards the General Agreement of Tariffs and Trade (GATT). These institutions favoured the development of the commerce which culminated in the globalization.

Theodore Levitt in "The Globalization of Markets" used for the first time the term "globalization" in the middle of the decade of the sixties. The Dictionary of the Spanish Royal Academy registers this entrance as the "tendency of the markets and the companies to extend, reaching a worldwide dimension that exceeds the national borders".

On the other hand, the containerization was born when the first ship that transported containers, the old T-2 tanker *Ideal X*, sailed with 58 containers, 33 feet long on board, from New York/New Jersey and unloaded them at the Port of Houston in April 1956.

At the beginning of the seventies, transport companies started to evaluate seriously the possibilities of standardizing the containers' dimensions. Transporters tried to make the use of the container compatible among different means of transport and different countries as well.

On November 9th, 1989, the fall of the Berlin Wall opened the way to the implosion of the Soviet Union in 1991 and the beginning of a new historical stage: the globalization.

THE BIGGEST CONTAINERSHIP OF THE WORLD FLEET

The recent incorporation to the world merchant fleet in the Far East - Europe line of the containership *Emma Maersk* is, without doubt, an event of maximum importance for shipbuilding and maritime transport: we are talking about a vessel capable to embark 12,508 *TEU*, when the major containerships up until to her incorporation (the series inaugurated by the *Xin Los Angels* last July 2006) were able to load only 9,574 *TEU*.

The main particulars of the *Emma Maersk* are:

Length over all	398.0 m
Length between perpendiculars	376.0 m
Breath moulded	56.4 m
Depth	30.2 m
Draft	16.0 m
Deadweight	156,907 tonnes
Gross Tonnage	170,794 GT
Capacity	12,508 TEU
Main Engine Power	80,080 kW (108,877 HP) a 102 rpm
Service speed	24.5 knots

Curiously, the specialized press has not dedicated too much attention to the event, in spite of the fact that the new vessel is the first one of a new generation of containerships: her dimensions have been increased from a total length between 335 and 350 meters to almost 400 meters, from a breath between 43 and 46 meters to more than 56 meters and from a draft about 14.5/15 meters to 16 meters. Also her depth has followed in the same path, jumping from about 25 to 27 meters to more than 30 meters. In other words, this new ship can be considered as the first one of a new series which, apart from magnitudes with numerical expression, represents not only a quantitative, but a qualitative jump in shipbuilding and maritime transport.

It is worth to say that the majority of the news of the maritime press have referred to the capacity of the new ship fixing it in approximately 11,000 *TEU*, though some media have indicated that her capacity could be bigger and, namely, we have had the opportunity to find out an Internet source that indicates that the ship can load between 11,000 and 14,500 *TEU*, incredible range, out of any logic in this area. The database of Lloyd's Fairplay assigns to the ship a capacity of 12,508 TEUs.

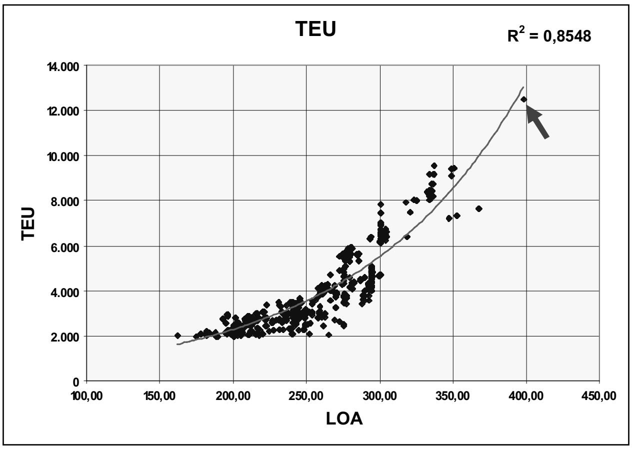


Figure 1.

A short analysis of the situation of the ship within the world fleet of containerships in service at the end of 2006 has allowed us to locate the ship absolutely out of the normal range of the fleet by that date. Nevertheless,

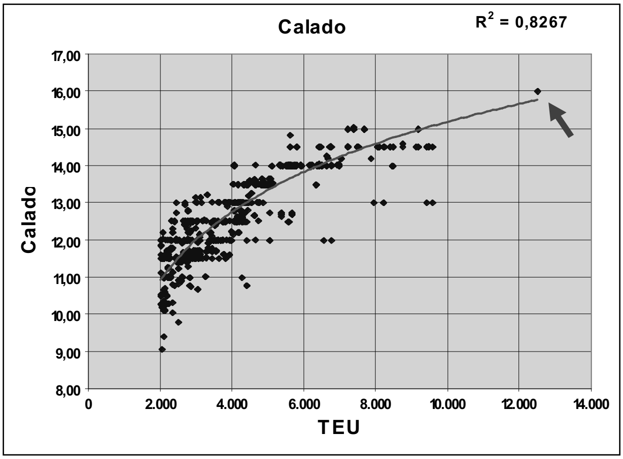


Figure 2.

— The correlation between capacity and length –with an adjustment degree rather acceptable for this type of ships (R^2 = 0.855)– shows the representative point of the new ship (pointed with an arrow) in a zone very close to which it would correspond to her in agreement with the trend line (Figure1).

— There is also a remarkable fitting of the new ship as far as draft is concerned, since also in this case the representative point of the ship is near the line of the corresponding trend (Figure 2).

THE ROLE OF THE MARITIME TRANSPORT IN THE GLOBALIZATION

Nowadays, it is a well-known fact that the world economy is in a process of increasing globalization characterized by a very remarkable increase of the commercial interchanges among all the nations, mainly founded on the development of the transport and the information technologies to an international scale.

In fact, nowadays, the economies of a great majority of countries are so intimately interrelated, that rich and poor countries constitute an economic set of difficult or nearly impossible separation. These are some of the reasons for the increasing use of the word globalization, in spite of the irritating, unjust and inexplicable differences of economic development between the countries that constitute this set.

The basic factors that have caused this evolution are, as one could easily guess, on one hand, the technological advance, especially in all kinds of communications and, on the other one, the gradual generalization of free market policies in the interchanges of commodities and capitals.

This way, the different countries have been more and more involved in the international traffic. The world trade has grown since 1950 to 2000 to a pace near to the double of the growth experienced by the world Gross Domestic Product, while the international trade of commodities and services has passed from constituting barely one-tenth of the world GDP to reach about one-third of the same one.

The geographical mentality has been progressively eliminated. There is one single economy and one single market, and any business has to be globally competitive, though it sells its products in a local or regional market. The competition is not local anymore; in fact, it has no limits.

In this context, a remarkable productive efficiency has been reached, based on three basic pillars:

— The incorporation to the productive chain of raw materials, components and semi finished products proceeding from wherever they can be obtained at a better price in reasonable reliability conditions.
— The use of a cheap manpower, with a reasonable productivity, often accompanied by the utilization of economic and tax advantages granted by the territories –it does not matter either where– in which the new industries are located.
— The development of modern, efficient and economic logistic chains.

Nowadays nobody doubts about the cardinal importance of a process that is making possible the transport of automobile vehicles from a continent to another at a cost under 1.5% of its origin price; or the transport of beer with a cost lower than 1 cent of US$ per can; or that has caused that today the great majority of the readers of this paper is wearing something in their clothes or shoes or bearing some electronic instrument that have been the object of a transport along several thousands of miles.

Maritime transport and shipbuilding have been, to a certain extent, advanced activities of this globalizing process, since they have been both immersed on traditionally globalized markets: shipyards have built ships for shipowners of the whole world and shipowners have contracted these vessels wherever they were more suitable for their quality, price or time of delivery, promoting this way the development of the shipbuilding activity in new countries, taking advantage very often of their excellent manpower and of their prices, considerably lower than those built by the traditionally builder countries; Japan was one day, Korea and China are today and other nations have started the way to be tomorrow paradigmatic examples of an industrial delocalisation that has favoured countries with developing economies to the detriment of the old, satisfied and ankylosed Europe.

This does not want to say, far from it, that the process of general globalization in which the world economy is immersed has not had consequences on shipbuilding and maritime transport. In fact, maritime transport is one of the factors that plays a most important role in the phenomenon of globalization, by means of facilitating the displacement of the raw materials, intermediate and finished products towards the points where they have to be transformed, from these towards those in which the final assembly of the products takes place, as well as and from the above mentioned towards the points of sale to the consumers.

Obviously, shipbuilding is a natural function of the development of maritime transport. An increase in the transport demand is followed by an increase in the demand of ships for transport at a world scale, which is materialized in an increasing demand of shipbuilding.

On the other hand, it is necessary not to forget that in both activities the characteristics of the globalization appear, though in a certainly peculiar form. In the maritime transport, by means of the use as productive inputs of resources coming from other countries: not only the ships are acquired in the most competitive markets, but crews, registration flags, technical and classification services, insurance, etc., are negotiated in a practically global context.

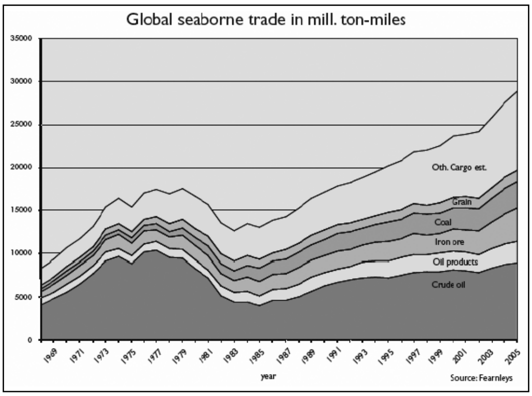
The current situation of the maritime markets shows the consequences of the globalization: a freight market that during the last three years (2004 to 2006) has reached record levels, taking the orderbook of the shipyards to figures never reached before, not even during the boom that preceded the first crisis of the energy in 1973. A great part of it has been just due to the development of zones traditionally depressed, like China, that have entered the economic game with an unusual strength.

THE FREIGHT MARKET

The current situation of the market of shipping as a consequence of the phenomenon of the globalization can be summarized with the following main features:

— Growth of the market
— Concentration of the suppliers of maritime services
— Specialization of the same ones
— Internationalisation of the maritime business
— Competitiveness

The maritime transport market has experienced throughout last years important increases, mainly in some sectors (Figure 3). Especially significant has been the recovery of the transport of crude oil after the crisis of the 70's and the 80's and the impressive increase of the general cargo transported in containers.



Source: AWES–CESA

Figure 3.

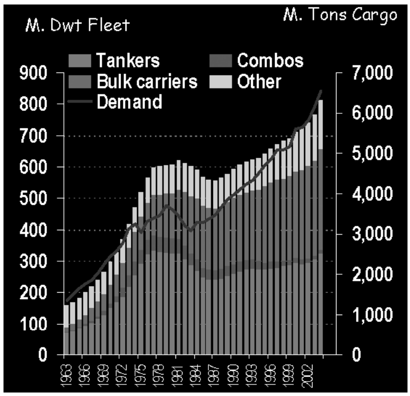


Figure 4.

Source: Stopford

Nevertheless, and despite the growth of the maritime market, nowadays there are less and less actors in the diverse sectors; in other words, a managerial concentration is taking place in a widespread form, as well as the specialization of the different production units in search of some type of comparative advantage that allows them to survive and to develop.

On the other hand, maritime business is getting more and more international, less tied to the trade of the country that develops the transport. In fact, the majority of the maritime carriers obtain most of their income by means of services between countries different from their own.

However, and in spite of the increasing concentration in the maritime sector, traditionally characterized by its atomisation, there has not been a decrease in its competitiveness, so, with fewer suppliers of services, the competition continues being strong and prices –in actual terms– decrease.

The increase of the trade promotes the increase of the transport and, in turn, a better transport produces a major trade, which generates better and/or more economic services, which again promote an increase in the commercial interchanges. It is the virtuous circle of the maritime trade, which has propitiated the widespread development of the most ample transport network of all kinds of commodities, safe, efficient and with competitive prices.

In this context of increase of the trade generated by the economic development of new geographical zones thanks to the widespread development of the transport, there is no doubt that one of the sectors that has contributed the most to it has been the unstoppable growth of the container traffic all over the world.

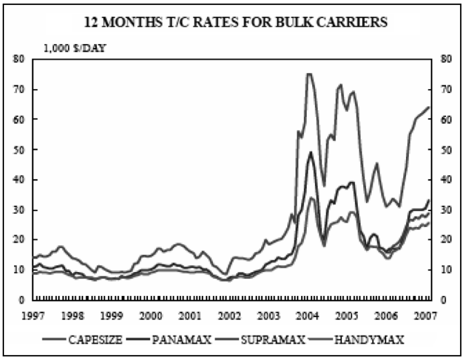
In order to take advantage of the economies of scale, this growth has been translated into spectacular increases of the size of these ships. Nowadays ships over 11,000 *TEU* are navigating, ships of even bigger size are under construction and still major ones are being studied and under negotiation, as well as ports with suitable draft, cranes and infrastructures to allow the use of giant ships.

Besides, the dizzy development in the general cargo transport has generated in parallel a huge demand of oil and dry bulks in the developing areas and this has propitiated that both dry bulk and oil freights have reached extraordinarily high values, with important profits for the shipowners, absolute records in the world of shipping.

Figure 5 shows in comparative terms the evolution, throughout last ten years, of the time charter freight rates for different sizes of dry bulk carriers. Something similar, though at a different pace and with other alternatives, has happened in the crude oil market, as it is shown in Figure 6.

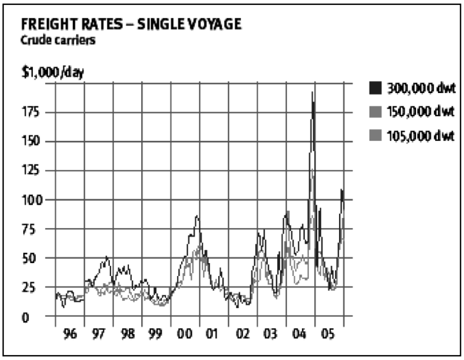
Also, and as far as general cargo is concerned, containers have allowed the shipowners to give the right answer to many traditional demands of users of maritime transport in regular line:

— Quick and safe transport.
— Competitive freights.
— Frequent services.



Source: *Platou*

Figure 5.



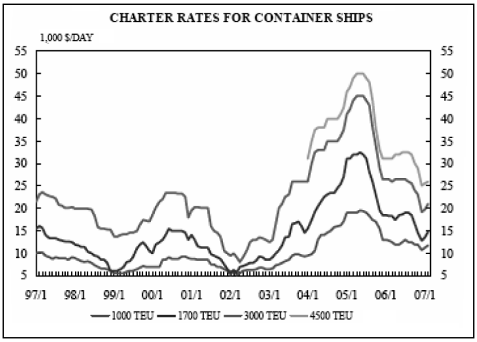
Source: *Platou*

Figure 6.

— Guarantee of services door to door.
— Direct lines between certain ports carried out by big ships.
— Global services, covering simultaneously many different traffics.
— Reduction of damages, thefts and deterioration of the commodities.
— Trustworthy systems of follow-up of containers, at any moment and everywhere.
— Simplification and reduction of paperwork and acceleration of steps and procedures for loading.

Maritime transport has passed from port to port to door to door system, in which impulse the development of logistics and intermodality has been crucial. The use of containers for the transport of commodities that traditionally did not use general cargo ships (cotton, paper waste, wood pulp, sugar, grain, etc.) has been generalised. Modern productive processes based on delocalisation have also been promoted, with an impressive transport of raw materials, semi-finished products, components, etc., to proceed to the different steps of the manufacture chain and to the final assembly. The need of stocks has diminished sharply, with the consequent reduction of unproductive investments. The supply of products has been made easier everywhere, with a more reliable and economic reception of them (just in time). The time in port of the ships has been reduced, in some cases from several days to stays of about 24 hours. Furthermore, the effect of the freight on the CIF cost of the goods has also experienced a reduction, although this one has not been yet especially significant in some geographical areas. The ports have evolved simultaneously to the ships, increasing their berthing lengths and their drafts, making easier the access of the bigger vessels. Infrastructures and superstructures have also been adapted to the new needs imposed by ships of bigger breadth, which has meant mega-cranes, able to handle containers stowed on the last rows far from the side of the wharf.

To summarize, a very high quality of the services has been generalized, with really competitive costs, which have allowed the consolidation of globalization, up to



Source: *Platou*

Figure 5.

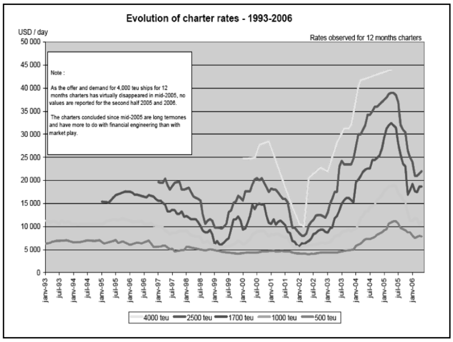


Figure 6.

Source: *Platou*

the point that in these moments between 60% and 70% of the seaborne trade –in terms of value– corresponds to commodities carried out in containers.

From a quantitative point of view, there has been a very important increase in the number of containerships, now a modern and competitive fleet thanks to the economies of scale, that have allowed the shipowners to survive throughout years of depressed freights, and that only during 2004 and the first half of 2005 seemed to find some compensation through higher freights (Figures 7 and 8). Afterwards things went worse again for shipowners.

The statistics of the demand show very substantial annual accumulative increases in the number of containers moved, especially in the traffics with the Far East, but as an average during last four years the global increase of the containers traffic has been near 12.5% in annual accumulative terms, able to explain the confidence of the shipowners in a market that for years has been at rather depressed freight levels.

How long can last such an exciting situation for shipowners? It is difficult to predict. The formidable development that China is having right now will sooner or later moderate, as it happened to Europe first, to Japan later and to the S. E. Asian countries now. But the truth is that China, with an annual accumulative increase of its bulk –dry and liquid– imports of near 20% throughout the last six years (2000-2006), has passed in the mentioned period of time from representing 9% of the world traffic of bulk cargoes to more than 21%. In fact, China, since 2006 is the world's top iron ore importer for the first time. Its exports on containers are also growing to a pace of about 30%. China is nowadays the locomotive of the development on a worldwide scale: with a trade over 1.1 billion tons, it is responsible of near 20% of the world seaborne trade.

Nevertheless, there is no doubt that after China, and following to some extent its steps, there are other Asiatic nations –such as India, Thailand, Vietnam, Malaysia,…–, some of which have already begun its development, that in a near future will produce new and important increases of the demand in the world economy.

THE KEY OF THE DEVELOPMENT: TRANSPORT CONNECTIVITY

Which is the main cause of this huge development? There is no doubt that globalization, strongly linked to transport expansion. And as far as the development is concerned, the transport of general cargo mainly in containers is, probably, one of the most important factors contributing to the progress, as it gives quick and safe multimodal regular services among most ports of the world. So the access to international markets requires efficient and economic transport services as a basic condition: door-to-door transport services, and "just in time" deliveries .The global trade would not be possible without global shipping networks, which require port reforms and investments in transport infrastructures, as well as trade and transport facilitation.

Nevertheless, in spite of the general improvements produced during the last decades, developing countries are still paying on average 70 % more for the international transport of their imports than developed countries. This is also a consequence of the low transport connectivity resulting from small tonnage to transport, poor port services, inadequate infrastructures, etc., which leads to low service frequencies and expensive services.

Transport infrastructure and costs are then important determinants of economic growth and foreign direct investment. Transport services are key determinants of the international trade and especially important for developing countries. Particular attention should be dedicated to landlocked countries, i.e., even countries that are not connected to each other through direct shipping services but must count on regular, albeit indirect, maritime transport connections.

Of course, the distance to and from major markets is one relevant factor of competitiveness of nations and it is directly reflected in transport costs. But there is another determinant of competitiveness, very important too, although often neglected: the transport connectivity, i.e. the access to regular, frequent and efficient transport services.

The access to liner shipping services is a crucial aspect of competitiveness. UNCTAD has developed recently possible measures that could serve as indicators of availability of liner shipping services and try to reflect the services, vessels and capacity deployed by international liner shipping companies in the different countries. The main parameters taken into account to establish the so-called Liner Shipping Connectivity Index (LSCI) in 2004 were:

1. Deployment of container ships
2. Deployment of container carrying capacity (TEU)
3. Deployment of container ships per capita
4. Deployment of container carrying capacity per capita
5. Number of liner shipping companies
6. Liner services
7. Average vessel sizes

8. Maximum vessel sizes
9. Vessels per liner shipping company

This index is elaborated then as a function of several magnitudes, selected because of their influence on the aptitude of the different countries for the development of a competitive trade. In 2006, UNCTAD decided to reduce those parameters, choosing five of the initial ones and recalculating the LSC-Index.

1. Deployment of container ships
2. Deployment of container carrying capacity (TEU)
3. Number of liner shipping companies
4. Liner services
5. Average vessel sizes
6. Maximum vessel sizes

With this information, and bearing in mind that the maximum value of the index for 2004 (the first year of its determination) was deliberately established as 100 for the country that reached the maximum punctuation (that was the same as one year later, Hong Kong, China), the initial classification have changed. The top of the rank is now occupied by China which implies a change in the positions before 2006. The results in 2006 (updated to July) are as follows:

Rank 2006	Country or territory	2006	2005	2004	Change 2006-05
1	China	113.1	108.3	100.0	4.8
2	Hong Kong (China)	99.3	96.8	94.4	2.5
3	Singapore	86.1	83.9	81.9	2.2
4	United States	85.8	87.6	83.3	-1.8
5	United Kingdom	81.5	79.6	81.7	1.9
6	Netherlands	81.0	80.0	78.8	1.0
7	Germany	80.7	78.4	76.6	2.3
8	Belgium	76.1	74.2	73.2	2.0
9	Rep. Korea	71.9	73.0	68.7	-1.1
10	Malaysia	69.2	65.0	62.8	4.2
11	France	67.8	70.0	67.3	-2.2
12	Taiwan Prov. of China	65.6	63.7	59.6	1.9
13	Japan	64.5	66.7	69.1	-2.2
14	Spain	62.3	58.2	54.4	4.1
15	Italy	58.1	62.2	58.1	-4.1
16	Egypt	50.0	49.2	42.9	0.8
17	United Arab Emirates	46.7	39.2	38.1	7.5
18	India	42.9	36.9	34.1	6.0
19	Saudi Arabia	40.7	36.2	35.8	4.4
20	Sri Lanka	37.3	33.4	34.7	4.0

This way it is possible to get a general indicator that reflects the availability of means in every country for the development of the international maritime trade.

China passes from an index 100 in 2004 to 113.1 in 2006 (an impressive jump); Hong Kong jumped from 94.4 to 99.3; and Spain, which have raised from sixteenth to fourteenth in the rank, improved its qualification as its index raised from 54.4 to 62.3.

Evidently, a high Liner Shipping Connectivity Index is indicative of the existence of a trade of containerised commodities in a country, which of course attracts the regular lines, which in their turn facilitate the trade and increase the competitiveness. The existence of infrastructures and services adapted for the regular lines contribute to increase the offer of transport and, in turn, attract new charges. Certainly, the big infrastructures allow the utilization of giant ships and the consequent reduction of costs through the economies of scale. It is the virtuous circle to which we referred above. In general a high Liner Shipping Connectivity Index is indicative of a country that has the means necessary for the development of the trade across its ports.

Usually a low index is indicative of more or less serious problems for the trade, and so, in some not developed countries, a low Liner Shipping Connectivity Index explains the need to incur in additional costs of transport for their imports and exports, which often means insurmountable charges for their economic development. But the fact that the Liner Shipping Connectivity Index of a certain country is low not always is indicative of lack of access of the exporters and importers of that country to regular lines for the trade of its products: it is frequent in Europe that some countries use as points of exit or entry for their commodities ports of neighbouring countries.

RISKS LINKED TO GLOBALIZATION

Finally, a few words about the risks linked to globalization. Because there is no doubt that on its turn, the globalization bears its own risks in a world in which violence and hate play an important role. Certainly, nowadays the risks of ships and ports are extraordinarily important.

Even though fortunately the number of acts of piracy is declining from its maximum reached in 2003, with a reported number of piracy attacks perpetrated against ships of 445 in 2003, 327 in 2004, 279 in 2005 and 239 in 2006 according to the International Maritime Bureau, there is no doubt that mega-ships and mega-ports constitute very valuable targets for the international terrorism. Both are subject of being attacked either from the sea or from the land. And ports constitute weak points in which a vigorous defence has to be articulated to prevent possible attacks.

In the modern globalized economy the vulnerability of the just in time logistics is very high. There are clear proves of it, as a simple strike of some more than fifteen days in certain points of the productive chain is able to stop the production in a very important percentage of the main assembly plants in the developed countries.

Hub ports constitute weak links of the chain of transport. What could happen with ships above 10.000 / 12.000 *TEU* in the market if there are not alternative ports able of giving the required service? In this regard it should be considered that ships' size is continuously increasing and logically there are less and less ports capable of receiving these mega-ships. A natural or provoked catastrophe in a mega-port could produce very serious problems of distribution, in case of not having an alternative port prepared to give the required service to the big ships.

What could eventually happen in Hong Kong, with arrivals of more of one ship per minute, handling of more than one container per second and an impressive number of passengers' movement in ferry ships?

And what could happen in the straits, actual choke points of the system? What would happen if a terrorist attack were able to block one of the most important routes of the world trade?

The application of the new codes of security in ships and ports (ISPS), as well as other still restricted measurements, such as the initiative for the security of containers (CSI), although with the difficulties inherent to any new regulation, will provide a new and valuable guarantee to the maritime trade.

The oceans constitute a kind of a great void, certainly propitious to spectacular assaults. And the ports are subject to an incalculable risk, about which often the insurance companies do not want to talk.

Terrorism in this field can be carried out from land, sea and air. Especially, and perhaps this is the most serious threat, the submarine terrorism can be practised without any need of emerging to surface, either by means of the use of sophisticated weapon technologies or acting by means of persons decided to their own sacrifice.

It is necessary to bear in mind that any ship is capable of turning into a weapon or into a means of transport of a lethal load. She can be attacked both from her inside and from the outside of the same. Among the shipments that can be loaded there are dangerous cargoes, able to provoke the desire of terrorist groups to explode the ship in port zones or their surrounding areas. Finally, among the risks it is necessary not to forget the transport of chemical, bacteriological or nuclear products with illicit purposes.

The risks are, therefore, enormous, and to the developed countries, responsible of a great percentage of the total movement of commodities corresponds the greatest part of this fight against the terrorism, and they are working in that way. It is a huge challenge, probably without any precedent in the maritime field.

CONCLUSION

We are immersed in a globalized economic system. This has been possible due to the development of a modern, efficient and economic maritime transport system. Particular importance in this process is having the development of a fleet of enormous container ships deployed on the main regular lines.

Although maritime transport is an activity that traditionally has been globalized, nowadays globalization is perhaps the main characteristic of all the fields of trade and industry, and this has also had a wide impact on maritime transport.

The connectivity between different zones of the world geography is an essential base for the development of the trade. The strong competition of the Southeast Asian countries, which has left the old industrial world in a precarious position in many industrial markets, has been possible thanks to the development of the shipping sector. This way the sharing of South Korea and China, among other countries, in the industrial world has increased remarkably. It has placed many traditional industries in a boring position. The only valid rule for the old industrial world to recover its strength will be the achievement of productivity in all the fields –industrial, economic, financial, etc.–, and these are the items on which it must concentrate. So there is one question on the table: will the old world be able to do it or its industry will end being a marginal activity?

On the other hand, globalization faces to another type of problems. Terrorism is, probably, the biggest one among them. Although some steps have already been taken, this is a problem not controlled yet and even in phase of expansion. It causes demurrages and costs and requires investments. Will the terrorism affect the economic global development? Undoubtedly, it is already beginning to be so. To what extent? This is another question that is on the table.

So there are some important questions opened before the future of the economic development related to the maritime industries. To what extent the old world is able to give an adequate answer constitutes, no doubt, the challenge that in this field is ahead of us.

Where are we going? Which will be the maximum size of containership in the future? Are the practical limits for this type of vessels the dimensions of Malacca strait? In that case, the 18,000 *TEU* containership could be reached in one, two, three jumps? And when? Could it be in the next ten years?

There is no doubt that there are too many questions to be answered in this paper. But one thing is clear: the growth of the containers traffic will be linked to the globalization of the commerce and so it will depend on its development.

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A SIMULATION MODEL FOR STRADDLE CARRIER OPERATIONAL ASSESSMENT IN A MARINE CONTAINER TERMINAL

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ABSTRACT

The globalization combined with the success of containerization has brought about tremendous increases in the transportation of containers across the world. This leads to an increasing size of container ships which causes higher demands on seaport container terminals and their equipment. In this situation, the success of a seaport container terminal resides in a fast transshipment process with reduced costs. For these reasons it is necessary to optimize the terminal's processes. The aim of this paper is to optimize the internal transport cycle in a marine container terminal managed by straddle carriers. Three sub-systems are analyzed in detail: the landside and the quayside transportation and the storage of containers in the yard. The conflicts and decisions that arise from these three subsystems are analytically investigated. Moreover, a decision support system (DSS) is developed in order to obtain valid results for the whole transport chain. Simulation has been used to compare different straddle carrier's operation strategies, such as single-cycle versus double-cycle, and different dimensions in the handling equipment fleet. The simulation model is explained in detail and the main decision-making algorithms from the model are presented and formulated.

Key words: Port operations, straddle carrier, container terminal optimization, simulation, operational research.

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INTRODUCTION

The purpose of this paper is to compare at operational level different strategies to assign straddle carriers (SC) to concrete tasks in a marine container terminal. There are four types of tasks for straddle carriers: to transport a container to the quay crane to be loaded in the ship (LQ), to pick up an unloaded container from the quay zone and deliver it to the storage yard (ULQ), to pick up a container from the storage yard to dispatch it through the truck gates (LT) and to receive a container from a truck and transport it to the storage yard (ULT).

According to the types of task that a particular SC can be assigned to, three assigning strategies can be defined. The single-cycle strategy, where a SC can only be assigned to one type of task, the double-cycle strategy where a SC can be assigned to both of the available type of tasks (L-loading and UL-unloading) but only in one zone (Q-quay zone or T-truck gates area) and the quadruple-cycle where a particular SC can be assigned to all types of task in any zone.

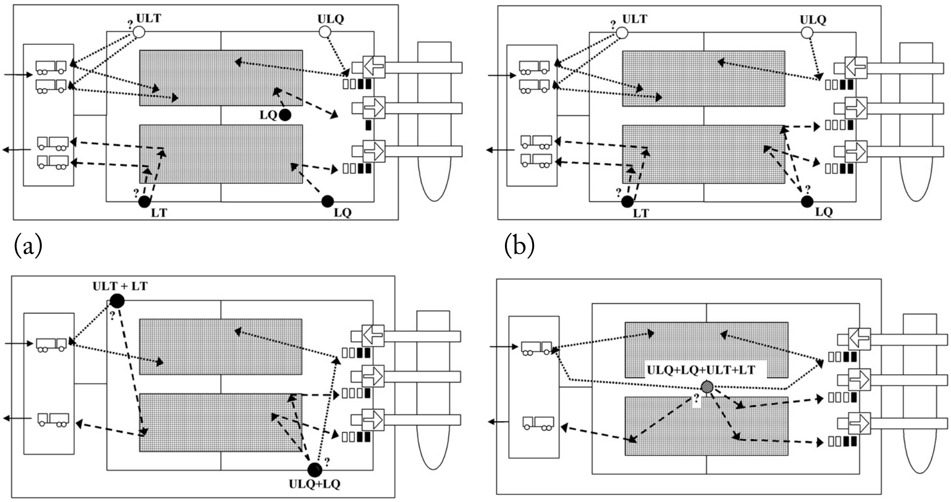


Figure 1. Available jobs depending on the SCs assignment strategy. (a) Single cycle. (b) Single cycle with quayside pooling strategy. (c) Double cycle. (d) Quadruple cycle.

The performances of these three assigning strategies are compared using a simulation model. Moreover, heuristic algorithms for the straddle carrier job assignment and for the allocation of containers in the storage yard have been developed.

ASSIGNMENT AND ALLOCATION ALGORITHMS

The optimum location of containers in the storage yard and the optimum assignment of tasks to straddle carriers are defined as NP-hard problems (1). For this reason, analytical solutions require a lot of constraints and do not consider the interaction of more than one subsystem. For example (2) analyses the berth allocation to ships, (3, 4) study the crane split (i.e. the allocation of quay cranes to ships and the ships' sections), (5, 6) analyze gantry crane productivity, (7, 8, 9) focus on storage and stacking logistics and (10, 11) use queuing theory to optimize quayside interconnection.

The goal of this research is to find an integrated solution for the three subsystems. For this reason, simulation is used as a tool to solve together all these problems and obtain an integrated solution. However, the simulation model needs three heuristic algorithms in order to support decisions in the following areas:

— Assigning jobs to straddle carriers and routing them.
— Allocating inbound containers in the yard.
— Allocating outbound containers in the yard.

The simulation model does not make decisions in allocating quay cranes to vessels and allocating vessels to berths neither.

In the next lines of the paper these three algorithms are presented.

Assigning jobs to straddle carriers

The algorithm has two main parts: identification of available jobs and assignment to SC of the best job.

In the berth area, there are two possible jobs to assign to straddle carriers, depending on which type of operation has to be performed: to pick up a container in the quay crane to bring it to the yard (ULQ - the quay crane is unloading a vessel) or to pick up a container in the yard to bring it to a quay crane (LQ - the quay crane is loading a vessel). In the truck gates area, there are two more possible jobs: to pick up a container in the yard to bring it to a truck gate (LT - loading an empty truck) and to pick up a container in a truck gate to bring it to the yard (ULT - unloading a truck).

The total number of available jobs to assign to a particular SC, depends on the straddle carrier's assignment strategy (simple, double or quadruple cycle). For example when a SC is operating in simple cycle in the berth area, only one job type is available as long as the SC is assigned to a quay crane performing only loading or only unloading operations (ULQ or LQ). It can happen that the SCs operate in pooling strategy; and they are not assigned to a particular quay crane, in order to achieve greater productivities (11). In this situation, for simple cycle, each SC is assigned to one process (ULQ or LQ) and the number of available jobs depends on the number of quay cranes that are performing this process. On the other hand, for landside operations each SC is only assigned to one process (ULT or LT) in simple cycle strategy. Then, the number of available jobs is the number of truck doors where this process (ULT or LT) will be carried out.

When the SCs are performing landside operations in double cycle, the number of available jobs is the total number of operative truck doors. The same happens at quayside interconnection in double cycle strategy, when the total number of jobs is the total number of quay cranes operating at the moment. Finally, in quadruple cycle the total number of jobs is the total number of operating trucks doors and quay cranes in the terminal.

Terminal Area	**Type of operation**	**Number of available jobs in Single Cycle strategy**		**Double Cycle**	**Quadruple Cycle**
		No Pooling	**Pooling**		
Berth Area	LQ	Only 1: transfer the next container of the crane's loading sequence from the storage yard to the under crane buffer.	1 to 5: equal to the number of cranes loading the same ship. Transfer the next container of the one of these cranes' loading sequence from the storage yard to the under crane buffer.	LQ +ULQ both in Pooling strategy	(LQ +ULQ both in Pooling strategy) + LT + ULT
	ULQ	1 to 4: equal to the number of containers unloaded and buffered under the crane.	1 to 20: equal to the number of containers unloaded and buffered under all the cranes that are unloading the ship.		
Tuck Gates Area	LT	Equal to the number of trucks waiting to be loaded		LT + ULT	
	ULT	Equal to the number of trucks waiting to be unloaded			

Table 1. Number of Available Jobs depending on the SCs Assignment Strategy.

Once the available jobs, depending on the strategy (simple, double or quadruple cycle), are identified, the next step is to evaluate an objective function for each one of these available jobs. Afterwards, the job which minimizes the objective function will be selected. Moreover, it has to be taken into account that a minimum service level has to be provided to quay cranes and trucks. Then, there is a minimum level of service for every job to be started that can not be exceeded. This minimum level of service depends on the operation to be performed. For example, loading quay crane is a more strict process than loading trucks, because a quay crane should never be waiting for a container. On the other hand, a truck can wait for the container to be loaded.

The objective in assigning jobs to SCs is to increase the service level by reducing the total time to perform the job. In order to reduce this total time it is essential to reduce the empty travel time between the ending of one job and the beginning of the next job. Another important parameter to minimize is the number of reshuffles, because more reshuffles implies more time to perform the job.

Operation	Acceptable level of service
LQ (loading quay crane)	Always one container waiting to be loaded.
ULQ (unloading quay crane)	Always one empty slot in the buffer capacity under the crane.
LT (loading truck)	Maximum waiting time to start the job 20 minutes.
ULT (unloading truck)	Maximum waiting time to start the job 20 minutes.

Table 2. Minimum level of service of different operations.

The objective function consists in minimizing the total cost of unproductive operations. If it is considered that a particular task "*j*" could be satisfied by several containers "*k*" of the same class, then:

$$u_{ijk} = C \cdot \left(r_{jk} + e_{ijk} \right) \tag{1}$$

Where: u_{ijk} is the unproductive cost for SC "*i*" performing task "*j*" with container "*k*".
C is the cost of SCs per unit time.
r_{jk} is the reshuffling time for task "*j*" with container "*k*".
e_{ijk} is the empty travel time from SC "*i*" location to task "*j*" and container "*k*" slot position.

The reshuffling time can be expressed as:

$$r_{jk} = \left(1 - z_{jk}\right) \cdot \left(L + 2 \cdot M + U\right) \tag{2}$$

Where: z_{jk} is the position in the stack of the container "*k*" required in task "*j*"
$z_{jk} = 1$ implies top position in the stack. No reshuffles required.
L is the time required by the SC to load one container.
M is the traveling time required for the SC to move to an adjoining position.
U is the time required by the SC to unload one container.

Finally, e_{ijk} is the travel time of the empty straddle carrier "*i*" from its position after finishing his last job "*j-1*" to the correct position to start the job "*j*" with container "*k*". The travel time includes the increase of time due to enter and exit to/from a container bay-yard.

$$e_{ijk} = \frac{\left\| \vec{C}_{jk}(x_{jk}, y_{jk}) - \vec{S}_{i,j-1}(x_{i,j-1}, y_{i,j-1}) \right\|_{dist}}{V_e} + q \cdot T \qquad (3)$$

Where: C_{jk} is the location of container "*k*" selected for task "*j*".
$S_{i,j-1}$ is the location of SC "*i*" after finishing task "*j-1*".
V_e is the speed of the SC when traveling empty.
q is the number of direction changes in the itinerary.
T is the extra time required for each turn of the SC.

The objective function in equation 1 is restricted to some constraints:

— Only one job can be done at the same time for each straddle carrier.
— Each straddle carrier can carry only one container.
— The number of available jobs to assign to each SC depends on the strategy used (simple, double o quadruple cycle).
— Each straddle carrier makes the decision to choose one job independently from the others, even though the jobs are shared by all the straddle carriers every moment.
— Between the available jobs, it is chosen the one that minimize the objective function. It has to take into account that there is a minimum service level that has to be provided to trucks and quay cranes.

The LT and LQ processes, both require a container class "*l*" from the stacking yard. But, there can be more than one container class "*l*" in the yard. Then, the container "*k*" with less empty travel time and less reshuffling time is chosen.

To solve this objective function (equation 1) in the simulation, a heuristic algorithm is used. The algorithm is a very simple mixed integer programming model, following logical decisions rules as branch algorithms.

First of all, the available jobs are identified: pick up a container from the quay crane (ULQ), pick up a container from the yard and bring to the quay crane (LQ), pick up a container from the truck door (ULT), pick up a container from the yard and bring it to the truck door (LT). As explained before, the number of available jobs depends on which strategy is used (simple, double or quadruple cycle) and on the total number of quay cranes operating "*n*" and the total number of operating truck gates "*m*".

Afterwards, the possible slots in the yard "*k*" that contains the required container class "*l*" to pick up in order to perform the job "*j*", are determined. Finally, the objective function is evaluated for each job and for each slot "*k*". The job which minimizes the objective function is selected. Sometimes is not possible to choose between all the available jobs because it is required to perform a particular job in order to provide the minimum service level.

Allocating outbound and inbound containers in the yard

There are three main strategies for allocating inbound and outbound containers in the yard. The container yard can be divided in two main parts: one only for outbound containers (waiting to be shipped) and the other for inbound containers (waiting to be delivered by truck or rail). One strategy could be to stack the inbound containers close to the quay cranes (quayside) and the outbound containers close to the truck gates (landside). This strategy is advisable when gantry cranes unloading rates are higher than loading rates (11) or when the terminal has a high transshipment percentage. If both flows are unbalanced, it is necessary to assign more bay yards to the biggest flow. The second strategy could be the opposite of the first one: inbound (landside) and outbound (quayside). Finally, all the containers could also be stacked everywhere in the container yard. There is no division in the container yard for stacking inbound and outbound containers in this last strategy.

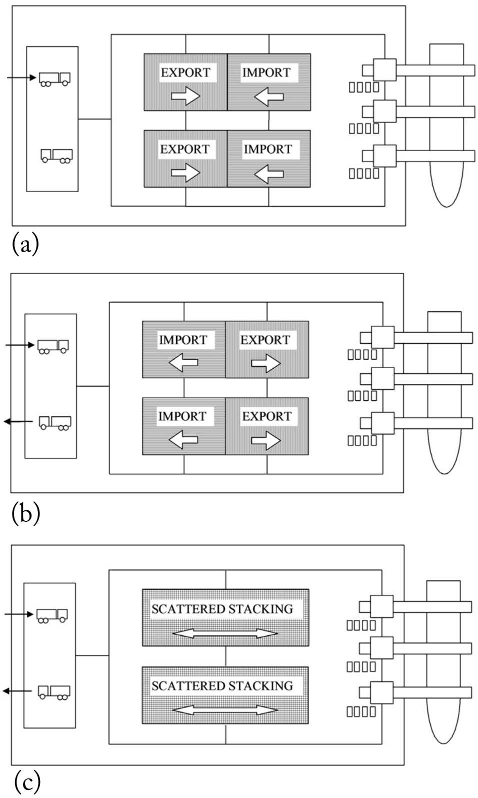


Figure 2. Main allocation strategies for import and export containers in the yard. (a) Import – quayside, Export - landside. (b) Import – landside, Export - quayside. (c) Scattered stacking.

Once one strategy is selected, it is needed to determine an allocating algorithm for inbound and outbound containers flow.

Allocating outbound containers

The outbound containers enter the terminal through the truck gates. The objective is to find an optimum slot "*k*" that minimizes the unproductive operational cost of equipment (i.e. empty travel time and reshuffles). Equation 1 can be used to determine this unproductive cost, taking into account that the empty traveling time for a slot "*k*" is the distance from the slot location to the scheduled berthing place of the outgoing vessel.

To evaluate the objective function it is necessary to allocate every container in a particular "*k*" slot position. For this purpose a DoS (duration of stance) technique is used. The main parameter to allocated outbound containers is the accessibility of this container for future operations. The

DoS technique is used to assign the higher accessibility container slots in the yard to containers with lower dwell time.

The allocating algorithm for outbound containers will have the following steps:

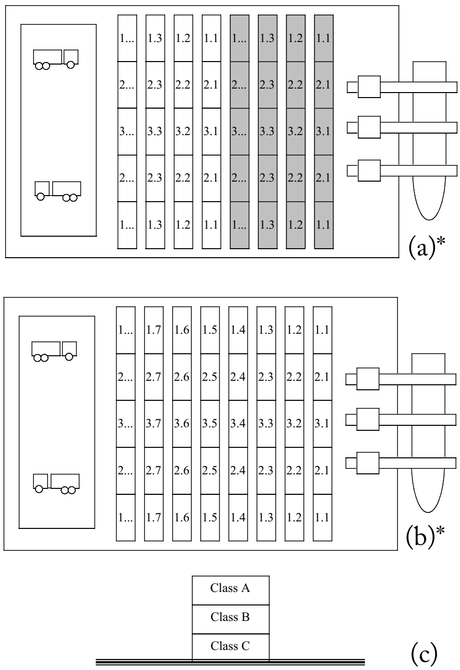
— Depending on the allocating strategy, the number of possible bay yards to stack the containers is defined.

— The accessibility determines the decision-making process. Depending on the dwell time of the container, the algorithm assigns the most suitable slot. The DoS rule works as follows: as lower is the dwell time better accessibility is needed. Then, the container with lowest dwell time will be allocated in the slot position with the best accessibility at this moment and vice-versa, for highest dwell time worst positions.

However, there is a big variance in container's dwell time and it is impossible to keep empty container slots waiting for the arrival of a particular container with lower dwell time, because it is impossible to know, for sure, that this container will arrive. For this reason three range of containers dwell times (A, B, C) are defined, depending on the range in dwell times. According to the dwell time class of a particular container, different starting point locations for the container are defined. The algorithm checks the best starting slot position depending on dwell tine container class. If this position is full, the second best one is checked and so on until an empty position is found.

For the A class containers, the best slot positions are reserved. These best positions are the most accessible slots of the container yard (i. e. the top positions of each stack). Among these top positions, the best are the ones located more closely to the transportation network of the yard (beginning and ending positions of a bay-yard) and located more closely to the quayside. For the class B containers, the medium stack slots positions are the starting point. In this case, a container can be placed on the top of them, needing a reshuffle to reach it. Finally, class C containers are stacked in the bottom slot positions. Two reshuffle operations could be needed in this case.

Figure 3. Accessibility of storage yard slot positions. (a) Different areas for import and export containers (b) Scattered stacking. (c) Elevation view.



*Note: The order of slot positions from higher to lower accessibility is 1.1, 1.2, 1.3, 1..., 2.1, 2.2, 2.., 3.1, 3..., ...

Allocating inbound containers

The objective is finding an optimum position for these containers in the yard, once unloaded from the ship. Again the objective is to reduce the empty traveling time of the straddle carriers and reduce the reshuffling in next operations (i.e. loading trucks operation). The problem in most of the world's terminals is the lack of previous knowledge of truck's arrival (only known few hours before). Then, it is very difficult to store containers minimizing reshuffle operations. The same DoS technique is applied in this case.

THE SIMULATION MODEL

The purpose of the simulation model is to compare different dispatching strategies for straddle carriers and to evaluate the suitability of the allocating algorithms proposed. This allows finding which are the best strategies to improve the service levels reducing transshipment costs.

The model is based on TCB (Barcelona Container Terminal). The model is a reduced-size model, due to the time costly developing process. Two blocks from the TCB are represented in the model. That supposes a total of 2700 slots positions instead of the 8.738 real slots positions.

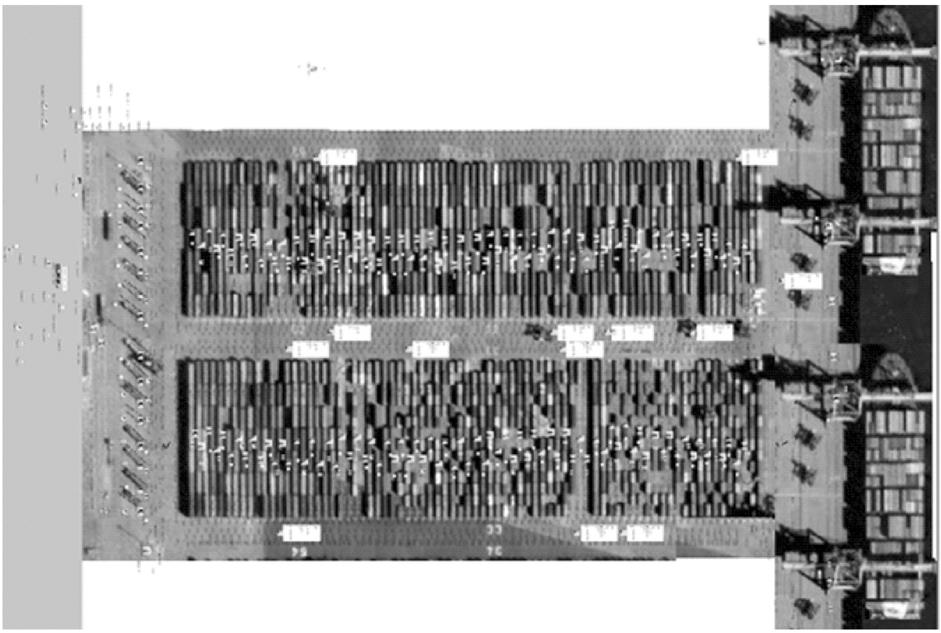


Figure 4. The simulation model layout.

Main	Quantity	Performance indicators
Ships	2	Unloading sequence of 250 containers. Loading sequence of 230 containers.
Containers	20 feet	Only general purpose 20 feet containers are considered in the simulation.
Quay cranes	4	Service time follows a triangular distribution. Loading rate: 23 cont/hour, σ=4 cont/hour. Unloading rate: 30 cont/hour., σ=6 cont/hour. 4 buffer slot positions under each quay crane.
Straddle Carriers	Variable to optimize	Stacking 3 containers in height. Loaded speed = 12 Km/h. Unloaded Speed = 16 Km/h. Speed inside a bay = 7 Km/h. Time to load/unload a truck: triangular distribution, μ=60s σ=20s. Time to load/unload a container from ground: triangular distribution, μ=30s σ=10s. Time to enter/exit a bay: triangular distribution, μ=5s σ=2s.
Storage yard	2700 slots	Stacking area of 4.74 Ha divided in two blocks o 2.37 Ha each. 75 bays per block, 7 rows per bay and 3 tier.
Trucks	Infinite queue	An infinite queue of alternative loaded and empty trucks is simulated in the entrance of the truck gates. Actually, the arrivals frequency of trucks depends on day hours. There are peak hours when trucks queue very long to enter the terminal. This assumption allows the simulation of the worst scenario.

Table 3. Physical configuration of the simulation model.

The simulation model is built following the QBM (quality-based modeling) technique (12). The main simplifications of the model are the following ones:

— Only one size of containers (40 feet) is considered.
— The weight of the containers is not considered. Neither IMO class nor voyage number (13), are considered.
— Only a general purpose container type is considered.
— The destination and the shipper are included in a new parameter: batch shipper's cargo.
— The number of containers in each shipper's batch is generated random between 1 to 50 containers.
— The dwell time of each container is divided in three main groups (A, B, C) and to all the containers from the same shipper's cargo is assigned one of these three possible dwell time classes.
— Each bay-yard of containers is accessible from both sides: left and right. Once the SC enters to the desired bay-yard from one side, it has to go out from the same side. This is a simplification in order to avoid possible physical contradictions and to give stability to the simulation model. However, in reshuffling operations all the container slots from the same container bay-yard are accessible by the same straddle carrier and furthermore, the SC does not have to exit the bay-yard through the same side that entered.
— When is needed to perform a reshuffle operation, the loaded container will be unloaded to the closest position to the container slot where the reshuffle started.
— The trucks have only simple cycle (they only unload or load a container). There is not double-cycle. Then, a truck that comes to unload a container afterwards cannot pick up another container.

During the simulation time there is an undefined queue of empty and full trucks waiting to enter the terminal. Actually, the arrival frequency of trucks depends on the day hours. There are peak hours where the trucks can make long queues to enter to terminal. The objective of this hypothesis is to study the worst scenario in peak circumstances (100% resources used: all trucks doors are full and all quay cranes operative).

The average of a vessel cycle in TCB is of about 18 hours. It is assumed that only the 60% of the vessel's stance time in the port corresponds to unloading and loading operations (i.e. 10 hours). The total duration of the simulation is 20 hours and 30 minutes hours. The objective is to create a time lag between vessels in order that all the operations coexist in a certain period of time. Table 4 shows the scheduling of operations for each vessel.

<table>
<tr><th>Time of simulation</th><th>Berth 1</th><th>Berth 2</th></tr>
<tr><td>0-2:30</td><td rowspan="2">Mooring
Administrative tasks</td><td>No vessel</td></tr>
<tr><td>2:30-4:00</td><td rowspan="2">Mooring
Administrative tasks</td></tr>
<tr><td>4:00-6:30</td><td>Unloading</td></tr>
<tr><td>6:30-9:00</td><td>Unloading</td><td>Unloading</td></tr>
<tr><td>9:00-11:30</td><td>Loading</td><td>Unloading</td></tr>
<tr><td>11:30-14:00</td><td>Loading</td><td>Loading</td></tr>
<tr><td>14:00-16:30</td><td rowspan="2">Administrative tasks
Exit</td><td>Loading</td></tr>
<tr><td>16:30-18:00</td><td rowspan="2">Administrative tasks
Exit</td></tr>
<tr><td>18:00-20:30</td><td>No vessel</td></tr>
</table>

Table 4. Loading and unloading operations for both vessels.

Considering this schedule of operations, and taking into account the average operational rates of the quay cranes, the number of containers to be loaded or unloaded in each phase is determined. This allows for considering the total time to complete each phase as a performance parameter for each simulation scenario.

This model is a practical tool able to compare different straddle carrier's operation strategies, such as single-cycle versus double-cycle or quadruple cycle. Besides, all these operation strategies could be also compared to different allocation strategies, such as half yard restricted to stack inbound containers and the other half to outbound, vice-versa or stacking in the entire yard without flow restrictions. From each one of these simulation scenarios, the number of straddle carriers needed to ensure an optimum service level it can be determined.

CONCLUSIONS

A particular container terminal can be very different from another due to the physical configuration and the handling equipment used. Furthermore, a container terminal is a complex system, since several operations have to be performed and a good coordination between operations is required. Simulation models can be a very efficient tool to compare, optimize or synchronize terminal's operations. On the other hand, simulation models are a time-consuming job to develop and validate. Nowadays a new concept, emulation, is growing fast. Emulation it can be seen as a simulation in real time with the real data from the terminal's system every moment. This new concept is available due to the technical advances in TOS (terminal operating systems) which supports terminal planning, scheduling and equipment control, creating a virtual. Emulation can be integrated in this TOS.

In the present research project, a simulation model is created in order to compare different allocating, dispatching and assigning strategies for a maritime container managed by straddle carriers. A good understanding of the simulation model and the algorithms used are necessary for a correct evaluating of the simulation results. Numerical results of the application of the algorithms in TCB (Barcelona Container Terminal) are not available yet.

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UN MODELO DE SIMULACIÓN PARA LA EVALUACIÓN OPERACIONAL DE STRADDLE CARRIER EN UNA TERMINAL PORTUARIA DE CONTENEDORES

Resumen

El fenómeno de la globalización, juntamente con el éxito de la contenerización ha propiciado un enorme incremento en el transporte de contenedores en todo el mundo. Esta situación ha llevado a un incremento en el tamaño de los buques portacontenedores, lo que supone unas exigencias mayores a las terminales y sus equipos.

En este contexto, el éxito de las terminales de contenedores reside en un rápido proceso de carga/descarga con unos costes reducidos. Por estos motivos cada día se considera más necesaria la optimización de los procesos de la terminal.

El presente artículo trata la optimización del subsistema de transporte interno en una terminal marítima de contenedores operada mediante straddle carriers (SC), uno de los equipos tecnológicos más ampliamente utilizados en las grandes terminales del mundo. Se analizan tres subsistemas en detalle: la interconexión lado tierra, el almacenaje de contenedores en la campa y la interconexión lado mar. Los conflictos y decisiones que conllevan las operaciones en estos subsistemas se tratan de manera analítica y se proponen algoritmos de optimización. Adicionalmente, se ha desarrollado un modelo de simulación para contrastar los algoritmos propuestos y para comparar las distintas configuraciones operacionales de la flota de SCs. El modelo de simulación se explica en detalle y los algoritmos de toma de decisiones se presentan y formulan.

METODOLOGÍA

En una terminal marítima de contenedores existen básicamente 3 procesos logísticos: la carga/descarga de buques portacontenedores, el almacenaje en la campa y la recepción/entrega terrestre de los contenedores. Adicionalmente, es necesario un cuarto proceso que asegure el transporte horizontal de los contenedores entre los tres subsistemas anteriores: el subsistema de interconexión. La operativa del subsistema de interconexión está estrechamente ligada al tipo de equipo utilizado, en este caso los SCs.

La configuración de las operaciones de los SCs en una terminal marítima de contenedores, depende de lo que se denomina "estrategia de asignación", que consiste en el proceso de asignación de las tareas concretas a las distintas unidades que conforman la flota de equipos de interconexión. En el lado mar existen dos tipos de tareas: recoger un contenedor que ha sido descargado por la grúa de muelle y llevarlo a la campa de almacenaje (tarea tipo ULQ), o la tarea inversa (LQ). A su vez en el lado tierra existen dos tipos más de tareas: recibir un contenedor y almacenarlo en la campa (tarea tipo ULT) o recoger un contenedor de la campa para entregarlo a un camión o ferrocarril (tarea tipo LT). Se pueden diferenciar tres tipos de estrategias en función de las tareas que están disponibles para un SC concreto: ciclo simple, ciclo doble y ciclo cuádruple (ver Fig. 1). Cuando una terminal opera en ciclo simple, solo un tipo de tarea está disponible para el SC. Por ejemplo, en el lado mar, un grupo de SCs están asignados a una sola grúa operando en carga o en descarga. Igualmente en ciclo simple los SC pueden trabajar en equipo. En este caso los SCs están asignados a un grupo de grúas, pero todas ellas operando en el mismo tipo de operación, ya sea carga del buque o descarga. En el caso de trabajar en doble ciclo los dos tipos de tareas (UL o L) están disponibles para un SC, pero en una sola área de la terminal (lado mar o lado tierra, pero no ambos). Finalmente en el ciclo cuádruple, todas las tareas puede ser asignadas a cualquier SC.

Para analizar en funcionamiento en términos de productividad y eficiencia de cada una de estas estrategias, se ha desarrollado un modelo de simulación basado en una simplificación de la Terminal de Contenedores de Barcelona (ver Fig. 4). Este modelo de simulación requiere algoritmos que le permitan tomar decisiones en dos aspectos:

— Asignación de tareas a los equipos.
— Selección de la posición de almacenaje del contenedor en la campa.

El algoritmo de asignación, trata de minimizar el tiempo improductivo de cada SC, mediante la reducción de las distancias de viaje en vacío y la reducción del número de remociones (ver ecuación 1).

A su vez, el algoritmo de almacenaje, está basado en incrementar la eficiencia en la rotación de contenedores, almacenando aquellos con un tiempo de estancia menor en las posiciones más accesibles de la campa (ver Figera 3). El algoritmo, considera las estrategias básicas de almacenaje habitualmente utilizadas en las mayores terminales del mundo (ver Figura 2).

CONCLUSIONES

Una terminal de contenedores puede ser muy diferente de otra debido a su configuración física y a la tipología de los equipos de interconexión utilizados. Por otro lado, una terminal de contenedores es un sistema complejo, donde distintas actividades deben coordinarse entre si. Los modelos de simulación pueden ser una herramienta muy potente para comparar, optimizar y sincronizar las operaciones de la terminal. Sin embargo, los modelos de simulación requieren un gran esfuerzo de desarrollo y validación.

En el presente artículo se ha presentado un modelo de simulación que compara distintas estrategias de asignación de tareas y de almacenaje de contenedores. Un buen conocimiento del modelo es necesario para la correcta interpretación de los resultados. Los resultados numéricos de la aplicación del modelo a la Terminal de Contenedores de Barcelona (TCB), aún no están disponibles.

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NEW TRENDS IN PORT MANAGING: TOWARDS THE E-PORT

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ABSTRACT

Nowadays it is becoming more and more difficult to gain land in sea water, due to greater environmental concern and port-city relationship.

Besides, a port should not fall into the trap of simply benchmarking against league tables, or falling for the common misconception that "by getting bigger we get better". Terminal performance and productivity are essential. Therefore we cannot forget technology´s helping hand in order to synchronise container handling from the quay to the yard.

Taking into account which was above mentioned, ports are continuously keeping its drive to operate a paperless port. However, all administrative procedures and ISPS Code requirements for compliance are met.

In order to achieve that every transaction between a company belonging to the port community and the port is done electronically, not with hard copy documents, thus coordination among all ports is critical.

In the paper, the case study of the Port of Vigo is also presented.

Key words: Ship and Port Operations, Shipping Information Systems, ISPS Code

INTRODUCTION

The arrival of maritime container in the middle of the 1960s led to a great improvement of freight transport in many aspects. The transfer of goods became much easier and safer and the use of containers paved the way for intermodal trans-

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port development. At present, the maritime container dominates the shipping industry and the extent of its influence in land transport is also substantial.

Through history, ports have developed as a node in the transport chain surrounded in many cases by the city. In fact, since the origin of navigation, natural harbours have been prime locations for urban development. However, nowadays, ports offer to their users a great amount of services, apart from loading/unloading goods. Due to the development of multimodality, door-to-door transport and the inviolability of the load unit, the loaders do not care about the intermediate ports their goods go through, before the arrival to the final destination. From this point of view, their only concern is to minimize the final cost of distribution, safeguarding at the same time the security of the service and that the merchandise arrives complete at the scheduled time. Consequently, ports should analyze its competitiveness and formulate its commercial politics from the client's perspective.

Everyday more, customers require e-solutions for the data exchange. Thus, the information society, based on network services which are of an increasingly commodity nature, presents many opportunities, but they are accompanied by almost as many threats. Sophisticated technology enables sophisticated services. The European Union is endowed with a rich heritage of nationalities, cultures and traditions. This is a great strength, but in the development of e-services, there is the danger of islands arising where language groups or national administrative borders interrupt the flow of services. It is with such challenges in mind that the Trans-European Telecommunications Networks policy has been set out.

On the other hand, freight transportation is a socio-economic activity of great importance for social, industrial and commercial processes. Recent years have seen meaningful changes in cargo handling techniques, amongst which the most important has been the introduction of containers. Their success mainly depends on the reduction of an almost infinite number of shapes and dimensions of goods to a small set of standardised units. In addition, the introduction of containers offers great advantages of security and ease of handling, and has transformed transportation activity from a port-to-port to a door-to door service. It is based on multimodality, in which the carrier guarantees freight transportation from initial shipper to final recipient.

Simulation modelling techniques are being applied to a wide range of port and terminal planning processes and operational analysis of container handling systems. These models have become extremely valuable as decision support tools during the planning and modelling of ship-berth link in a port.

A container port, which provides the interface between container ships, railroads and road trucks, represents a critical link in the intermodal transport to be fulfilled in the best possible way by management of container terminals. It is especially important in today´s competitive world of port and shipping business. Because the container port facilities are very expensive to run and terminal capacities are large and efficient enough to handle the changeable container flows during the considered periods of time. Determining the effect of changes in throughput, as well as the influence of various operational, technological and economic aspects on efficiency of container port operations, has been widely analysed by using port simulation models.

The crucial terminal management problem is optimising the balance between shipowners who request efficiency service to their ships and the economic use of allocated resources. Since both container ships and container port facilities are very expensive, it is desirable to utilise them as intensively as possible.

THE WAY PORTS TACKLE WITH SECURITY vs. OPERATION EFFICIENCY

As regards port security, it is well known that ports had to comply with IMO´s ISPS code as of 1 July, 2004. It seems that progress in implementing the Code in European Community Ports has been impressive, and all players concerned are doing their best to make this a success. However, in addition to the ISPS code, the European Community has also adopted a Regulation of ship and port security, which transposes the ISPS code into EU law. Parts of this Regulation are more stringent than the ISPS Code, by making mandatory some parts of the Code that are not mandatory. In addition to this Regulation, there is also a specific Directive on port security, which expands into all relevant port areas, and a plan for a future Directive on intermodal security! The draft Directive on intermodal security is dedicate to freight transport and aims to cover intra-community trade and also third countries trade in transit on EU territory.

On top of all this, one also needs to add the various bilateral and global US-EU agreements under the Container Security Initiative umbrella.

Thus the scenario seems to be not very promising for operational efficiency and productivity in ports.

In view of these developments, one cannot avoid asking some questions.

Perhaps the most naïve of these is, how much all of these measures would really enhance EU port security. In my opinion, nobody really knows, although the general perception is that security would increase. However, the question is at what cost. Everybody ask about the total cost of these measures, because there is a huge number of people living on security worldwide. There are some consultancy work on this issue, but not including external costs.

Yet another question is whether there is an estimate of the impact that these measures might have on trade and on the goal to shift cargoes from road to sea (what about motorways of the sea, i.e. the so called MOS?). On the one hand, EU keeps promoting the development of MOS through Marco Polo and other funds, appart from the legislative point of view. However, on the other hand, administrative and security procedures, for ship and cargo, are much more burdensome in maritime transport rather than in road transport, where are almost inexistent.

Finally, everyone wonders if ports will be able to operate efficienly, at a reasonable cost, under these measures.

TECHNOLOGY´S HELPING HAND. CASE STUDY: THE PORT OF VIGO

As regards port operation, there are two main ways of influencing terminal performance. On the one hand, gate systems and CCTV (related with port security). On the other hand, increasing port productivity, by predicting, for example, truck arrivals to terminal through the internet tracking (no longer hard copies are required). To achieve this goals, bridging the gap and getting ahead, ITs are essential.

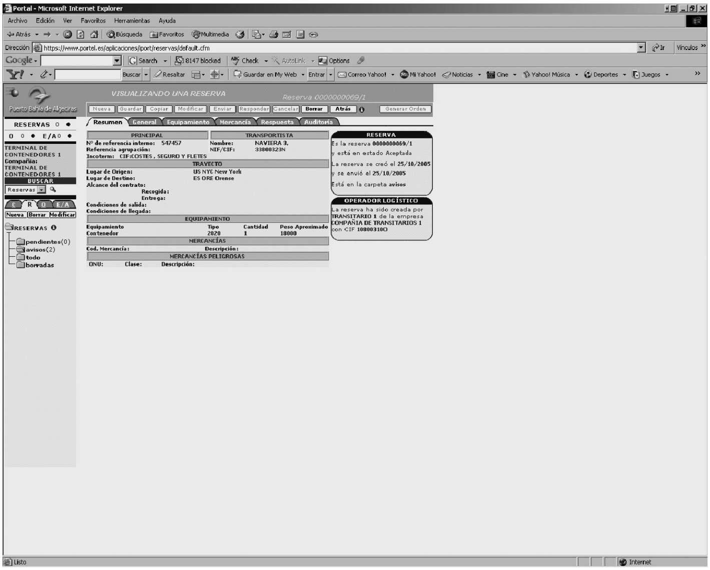
Nowadays the Port of Vigo is developing the I-Port project for the exchange of information between the agents of the Port Community and the Port Authority of Vigo, through the internet. It is a Port Community System. Basically designed to improve the operating processes of ship and cargo agents and operators (forwarding agents, shipping agents, carriers, etc), this platform will make it possible, amongst other things, to conduct all the transactions required to get the goods out of the port. It will be the a one-stop shop for the electronic exchange of information between the Port Authority of Vigo and companies in the Port Community.

From the point of view of securtity, this IT platform will allow Port Authority to know in advance which truck&cargo is going to enter the port. Thus, the information available increases considerably, in comparison with nowadays.

The I-Port web platform try to consolidate itself as the main tool supporting the operations between said agents by:

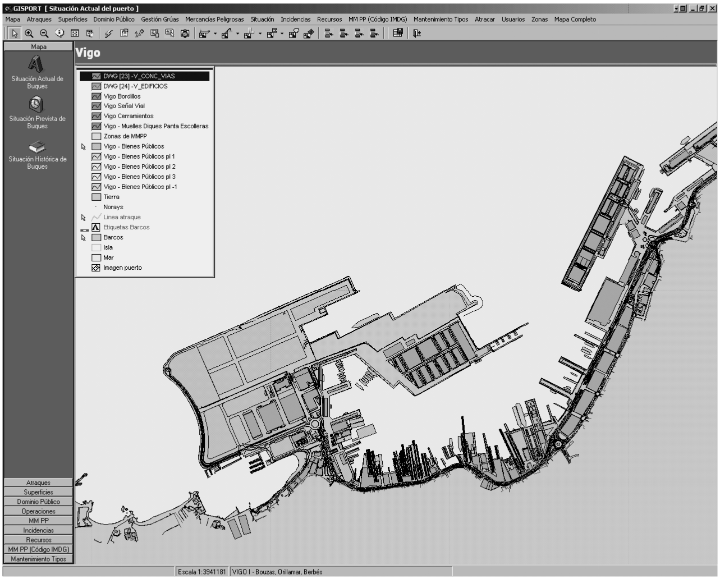
— Modernising logistic management: employing standardised information exchanges to facilitate business and administrative procedures and operations concerning cargo movements at Vigo port.
— Sea-Port-Land integration: by extending the integration between the Port Community on both the “land” side with haulage operators and on the “sea” side thanks to its integration with the world’s leading shipowners via INTTRA. This means that users will be able to view the entire transport chain in the portal.

A general view of the I-PORT web is:



Appart from this software we have developed a completely integrated managing system which comprises CCTV and access control, based on a automated gate system. Thus, its a multipurpose software accessible simultaneously from different users.

Finally, we have developed a GIS to optimise berth allocation and port operations, taking into account ISPS compliance and hazardous cargo legislation.



All these iniciatives try to apply technology´s helping hand in everyday managing, in order to minimise the time the cargo remains in the port and to optimise human resources, taking into account that it is becoming more and more strict the legislation related to safety, security and environmental issues.

CONCLUSIONS

As a summary, it is asserted that contemporary container ports face much fiercer competition than before and that to survive in this competitive environment, modern container ports need to look at all the factors influencing port performance, both externally and internally. Externally, a port needs to understand the changing demands of its customers and to recognise, and attach greater importance to the position of ports within the context of a grid of global supply chains in which they participate. Internally, container ports need to reduce any slack in production in order to ensure sustainable development and competitiveness, complying at the same time with security requirements.

Because port costs are increasingly passed onto customers, in the long run, reducing slacks in port production to a minimum will ultimately benefit the whole supply chain and most port users.

Therefore, in order to archive this target, it is required to use IT nowadays.

Thus the e-port is here!

NUEVAS TENDENCIAS EN LA GESTIÓN PORTUARIA: HACIA EL E-PORT

RESUMEN

Hoy en día, cada vez es más difícil ganar terrenos al mar, habida cuenta la creciente conciencia medioambiental y la presión del crecimiento urbano de la ciudad en la mayoría de los puertos del mundo.

Asimismo, un puerto no debería caer en la trampa de considerar que únicamente "incrementando su tamaño, mejora". Los estándares de servicio y productividad de la terminal son aspectos esenciales a tomar en consideración. Por otra parte, no se puede olvidar la mano que tiende la tecnología, al objeto de sincronizar la manipulación de contenedores desde el buque al patio de la terminal y viceversa.

Tomando en consideración lo arriba mencionado, los puertos están esforzándose en gestionar un puerto sin papeles, optimizando procesos y garantizando en todo momento el cumplimiento de la legislación administrativa y los requerimientos del Código ISPS.

De este modo, este sistema implementado es mucho más seguro, desde la perspectiva de la protección, habida cuenta que los camiones no son autorizados a acceder a la zona de servicio del puerto, salvo que la orden de carga haya sido recibida electrónicamente con antelación por la terminal.

A mayores de este proceso "sin papeles", es preciso tener en cuenta que la gran mayoría de los puertos han implementado un sistema de reconocimiento automático de matrículas en los diversos puntos del control de acceso. Y es que el mundo tras el 9/11 ya no es el mismo.

Todas estas iniciativas pretenden minimizar los posibles retrasos en el tránsito de las mercancías por el puerto, derivados de dar cumplimiento a lo legislado en el Código ISPS y demás legislación de protección de aplicación.

En este trabajo, el ejemplo del Puerto de Vigo es también presentado.

Palabras clave: Buque y operaciones portuarias, TICs en el transporte marítimo, Código ISPS

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STUDIES OF SUITABILITY ON SHORT SEA SHIPPING ROUTES IN SW EUROPE

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ABSTRACT

Around 45% of European Union (EU) foreign trade is carried by road, which is conditioned by traffic congestion and high fuel consumption, and lead to implying the pollution and safety problem. Short Sea Shipping forms another 40% of the EU foreign trade. National and European governments have considered the Short Sea Shipping in European waters as one of the most feasible ways to alleviate the congestion which is getting worse each day on roads and highways in Europe. The main aim of this paper is to both study and identify the feasible routes in SW Europe which appear to be a viable solution for avoid road transport problems.

Key words: short sea shipping, routes, intermodality parameters, Iberian Peninsula.

INTRODUCTION

The European Commission and Member States realized that transport in Europe is growing at a high rate and that beyond 2010 (White Paper, 2001) it is possible the figures for inter European transport, including the new accession countries, will show a growth of over 80% in volume, and unfortunately these values will be absorbed mostly by road transport. However, road transport supposes higher environmental problems than marine one, such as congestion, superior values of pol-

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lution, noise, accidents and etc. Thus, a big commitment is needed from all those involved in order to improve alternative ways to guarantee the flow of cargo. Short Sea Shipping appears to be a potential choice for the European Union and it is also one of the pillars of the community's transport policy. In short, we could observe that shifting traffic from road to sea is adopted as a main policy goal.

The main obstacles in promoting intermodality are the costs, legal system, European infrastructure problems and less developed transport chains (Blonk, 1994). The main aim of this paper is to both study and identify the feasible routes in SW Europe which appear to be a viable solution for avoid road transport problems.

This paper has been divided in two main sections. Firstly, some previous research in this field of our research group is described. Secondly, different variables based on multimodal transport are evaluated and scoring system is established for determine short sea shipping routes in SW Europe.

PREVIOUS RESEARCH

The previous research carried out by the TRANSMAR research group integrated in the Technical University of Catalonia was the INECEU project, proposing after an exhaustive study some alternative multimodal lines against road transport. Keeping in mind the figures of road traffic passing the Pyrenean borders, the group analysed most of the volume moved between Spain and France. Among all the Spanish regions we should note the activity of Catalonia, the Basque country, Valencia and Andalusia. The French counterpart is contested by the Pyrenean regions of Aquitaine, Languedoc-Roussillon and Midy-Pyrenees together with Ile-de-France, Rhône-Alps and Provence-Alps-Côte d'Azur. The French territory is also crossed by important traffic fluxes southbound coming from Westafalia, Baden-Würtemberg and Bayern in Germany and the northern part of Italy. From Spain it is possible to identify the main traffic towards Westfalia and Baden-Würtemberg in Germany, Lombardia in Italy and destinations more spread out up in Great Britain, Holland and Belgium. Regarding the nature of the cargo, we should note that the South and South-East part of the Iberian peninsula, together with the Valencia coast, are big producers of fruits and vegetables, with the group of manufactured or canned food and alcoholic drinks. This is one of the larger cargo groups that is exported from Spain. There is important traffic involving solid bulk such as building materials or scrap iron, together with oil and chemical products from ports with refineries nearby that are firmly committed to removing trucks carrying dangerous or toxic substances from the road to ships that have specifically designed containers, or Ro/Ros, that will benefit society as a whole.

The study concluded that:

1. The industry in the Mediterranean basin accepts the concept of Short Sea Shipping preferring destinations in Italy or further;

2. The Atlantic bulk traffics should take advantage of the SSS funding and official policies using multi purpose ships for accepting different kinds of traffic;
3. Fast ships could be justified when serving trips less than 12 hours away and when cost is not so important provided a minor time of delivery can be guaranteed;
4. The conditions shown in the first phases of the study can be submitted to change that, we are convinced, will be more advantageous to the ship.

IN DEEP STUDY OF SUITABLE ROUTES OF SHORT SEA SHIPPING IN SW EUROPE

Methodology of Study

The proposed study is based on a previous state of the art (Olivella, Martínez and Castells, 2005) coming from available data from statistics and previous research, where 15 routes were found based on estimated time and cost between multimodal and road transport. The objective of this paper is to reduce these 15 proposed routes to 4. In a second phase a group of parameters affecting the cargo flows balanced are considered depending on the importance empirically considered by the researchers. Every parameter has been an individual project with his results. All information collected for every individual project requires finally a careful evaluation to link the analytical results with the initial objective. In a third phase the preliminary results are going to be obtained from the previously defined algorithm.

The parameters considered in this work, which relevant to multimodal and road transport, are summarized as followed:

Variable
1. Difference of multimodal and road transport distance/time relation
2. Difference of multimodal and road costs
3. Freight Flows by road
4. Intermodality ports adequacy
5. Meteorological factor
6. Hinterland GDP
7. Hinterland population

Table 1: Variables

The selected parameters are briefly explained below:

1. *Distance/time relation.* The main goal of this variable is to evaluate saving in terms of distance and time between multimodal and direct road routes.

Data for maritime distances is obtained from *BP Marine, Worldwide Marine Distance Table, and version 1.2.1 software* while data for road distance is obtained from *AutoRoute of Microsoft software*.

Some assumptions in load/unload port time has taken into account in maritime journeys. The loading and unloading time taken to port varies relying on the types of ship used and handling operation in Spanish ports. Therefore, studies in terms of time have been conducted and finally, 3 hours minimum has been considered (1.5 hours in each port).

2. *Cost.* In order to calculate the generalized costs, all other parameters are required. For calculating freight road transport cost, a start off charge in time unit and a cost by weight or transport unit; both need to be estimated. According to the data from *Observatori de costos del transport de mercaderies per carretera a Catalunya*, amounts of 252.9€ per working day (nine hours per day) and 28.11€ per hour for 25 tonnes of long haul road unit have been considered together with a cost per kilometre of 0,337 with tolls.

Some statistical research has been studied on maritime transport costs, which consider charges from various maritime companies on different kind of fleet. Consequently, an average of unitary cost of maritime transport has been considered for a 12 meters truck in agreement with the road haul truck. Cost is 39.16 € per lineal meter of transport (Sener, 2003), including port operation costs. Truck cost is 469.92€, and associated cost for the port operations is estimated to be 120 € for each port while the maritime distance between both ports is 352 miles. Maritime haul cost per mile by truck is 0.653€/mile.

3. *Road freight flows.* The hinterlands of each port area are defined within the Spanish Autonomic Communities framework. This allows freight flow statistics to be taken into account on the hinterlands, providing an accurate means of comparison between the routes.

Statistical data is obtained from *Encuesta Permanente de Transporte de Mercancías por Carretera 2004* (Ministerio de Fomento, 2004), undertaken by Dirección General de Programación Económica, del Ministerio de Fomento. Road Freight flows have been calculated for each Autonomic Community. Two parameters are provided as follows:

— Total freight volume movement: Total of international volume received and issued.

— Flow Imbalance: The difference in the movements of freight between received and issued flows. A high value of this parameter gives a negative indication for Short Sea Shipping.

Various assumptions are made to determine this parameter. After studies being conducted on some references in new short sea shipping routes (Napier University, 2003), 60% for total freight and 40% for imbalance have been selected.

4. *Intermodality port adequacy*. Current conditions for Spanish ports are evaluated for all routes in this section. The following points are considered:

— Intermodal Traffic: Container and ro-ro are ideal traffic for Short Sea Shipping since these cargoes types allow shifting between different types of intermodal transport. Container and Ro-Ro traffic volume and their evolution from 2003 to 2004 are taken account in Spanish ports.

— Intermodal communications: Port should exhibit good interior and exterior accesses by both, road and rail. These accesses must guarantee good communication between port, wharfs and terminals and also with other external port and its hinterland. It is necessary to guarantee good link between all modes of transport within an intermodal chain.

— Intermodal port infrastructures: Ports have to present container and ro-ro terminals for short sea shipping traffic. If not, it would be necessary another non-specific terminal with minimum equipment necessary. Moreover, ports must have wharf with sufficient length to harbour difference ships simultaneously. It would be necessary to consider a ship is capable of embarking several categories of unitised freight: containers, road trailers or complete trailers. The size of the ships is subject to constraints in terms of the traffic potential considered and the average characteristics which are: length of 141.52 meters, beam of 21.56 meters, draught of 7.35 meters, mean GT 14722.64 and average speed 18.27 knots[i].

10 Spanish ports have been evaluated in this work. Four of them lead the total traffic in 2004 since they have more proper equipment, terminals and made up of good infrastructure. However, they encounter congestion problem. Evaluation of secondary ports for short sea shipping traffic has been conducted for the intention of promoting these ports alleviating the main ports.

5. *Meteorological factor.* Weather factor has been considered from current Mediterranean and Atlantic meteorological buoys data of Governmental Meteorological Institutions (meterological webpages, 2006). Conventional and high speed craft has been considered. Conventional ships do not present any mandatory regulation related to weather factor, authors have considered significant height wave related to seaworthiness and crew/passage comfort. HSC Code and Classification Societies establish operational limits for high speed craft. Meteorological factor is more critical in fast ships and high speed crafts than in conventional ships.

6. *Hinterland GDP.* GDP measures economic activity for an area. 2003 Autonomic Community GPD, which used in this research, is obtained from Statistics Government Data (Ministerio de Educación y Ciencia, 2005)

7. *Population hinterland variable:* Data collected by *Instituto Nacional de Estadística* (Instituto Nacional de Estadística, 2005) has gathered population for every Autonomic Community.

[i] Mean Characteristics of ships operating on Short Sea Shipping routes study. Transmar Group Research.

Preliminary results

A scoring system that takes into account seven variables has been chosen. The importance of each variable is indicated by a weight. The weight of each variable is calculated based on different perspectives, according to the following assumptions:

— Point of view from shipper/customer: A high level of service must be offered. High degree of frequency with a short transit time is the quality expected by the shipper. Distance /time relation and cost are considered the main variables.

— Point of view from general transport: The most important parameter is the roads congestion on the basis of flows. Road freight flows variable is applied with more weight than the other.

In both cases, 5% weight is applied to Hinterland GDP and Hinterland Population variables. By considering all assumptions and by making comparison with actual scenario of short sea shipping traffic, the following scores are used:

Variable	Variable weight (%)
1. Difference of multimodal and road transport distance/timerelation	25
2. Difference of multimodal and road costs	25
4. Freight Flows by road	20
3. Intermodality ports adequacy	15
3. Meteorological factor	5
5. Hinterland GDP	5
6. Hinterland population	5

Table 2: Scoring system.

Route	d/t (25%)	Costs (25%)	Flows (20%)	Inter. (15%)	Meteo (5%)	GDP (5%)	Popul. (5%)	Result
Route 1	-0,45	0,98	0,78	0,60	0,012	0,10	0,15	2,166
Route 2	0,29	3,17	0,52	0,45	0,012	0,05	0,20	4,696
Route 3	1,36	0,94	0,52	0,60	0,012	0,05	0,20	3,682
Route 4	0,20	7,56	0,78	0,60	0,012	0,10	0,15	9,402
Route 5	0,57	9,77	0,78	0,45	0,012	0,10	0,15	11,835
Route 6	0,24	8,37	1,76	0,30	0,013	0,15	0,20	11,041
Route 7	-0,53	1,89	0,30	0,60	0,012	0,10	0,05	2,422
Route 8	0,73	11,87	0,33	0,30	0,010	0,15	0,15	13,537
Route 9	1,04	0,67	0,33	0,30	0,012	0,10	0,10	2,550
Route 10	1,44	-0,05	0,33	0,60	0,012	0,10	0,10	2,532
Route 11	0,45	13,14	0,52	0,45	0,002	0,05	0,20	14,815
Route 12	0,68	5,63	0,30	0,60	0,002	0,10	0,05	7,354
Route 13	0,71	5,72	0,33	0,45	0,002	0,15	0,15	7,512
Route 14	0,52	9,38	0,33	0,45	0,002	0,10	0,10	10,881
Route 15	0,71	5,49	0,33	0,30	0,002	0,10	0,10	7,038

Table 3: Selected routes.

Once applied the weighing factors, the selected routes are the following ones:

Route 11	CTM Sevilla	Huelva	Hamburgo	Berlín
Route 8	ZAL Azuqueca de Henares	Valencia	Nápoles	Nápoles
Route 5	CTM Sevilla	Cádiz	Génova	Milán
Route 6	Zal Barcelona	Barcelona	Civitavecchia	Roma
Route 14	CTB Benavente	Gijón	Hamburgo	Berlín

Table 4: Final routes.

CONCLUSIONS AND FURTHER RESEARCH

Scoring model and hypothesis have been applied to 15 possible routes. Five feasible and viable routes have been identified and the potential to avoid the road transport problems and shift freight from road to sea, will lead to more integration of the economy between the regions of the Spain coast and Europe. It serves as a starting point in creating possibility for new regular short sea shipping lines.

Spain is a peripheral country that makes the short sea shipping a viable option for roads congestion. This would contribute in limiting the saturation of the main transport routes and thus could preserve the environment.

Further research in short sea shipping is necessary. Although Short Sea Shipping is not a new option for transport, studies on making possible improvements for it is crucial such that it could be the best option of transport. Improvements could actually be realised in all parts of the transport chain. Further research intends to evaluate routes described above in more details. In addition different kind of ships will also be evaluated (which include fast and high-speed ships). Some technical criteria will be looked into such as the ratio of time at sea to time in port and the frequency of services.

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IDENTIFICACIÓN DE LAS RUTAS VIABLES POR TRANSPORTE MARÍTIMO DE CORTA DISTANCIA (SSS) EN EL SW DE EUROPA

Resumen

Alrededor del 45% del comercio exterior de la Unión Europea (EU) se realiza por carretera, condicionado por la congestión del tráfico y el alto consumo de combustible, implicando problemas de contaminación y seguridad. El Transporte Marítimo de Corta Distancia (Short Sea Shipping) representa el 40% del comercio exterior de la EU. Los gobiernos Nacionales y Europeos han considerado el Transporte Marítimo de Corta Distancia en aguas europeas como la justificación del trasvase de mercancías para aliviar la congestión que cada día es peor en las carreteras y autopistas de Europa. El principal objetivo de este artículo es el estudio e identificación de rutas viables en el SW de Europa como una solución óptima para evitar los problemas del transporte terrestre.

METODOLOGÍA

El estudio propuesto está basado en trabajos anteriores (Olivella, Martínez y Castells, 2005) donde se hallaron, a partir de datos estadísticos e investigaciones previas, 15 rutas basadas en tiempo y coste estimado entre el transporte multimodal y por carretera. El objetivo de este artículo es reducir estas 15 rutas propuestas a 5. En una segunda fase, se han establecido unas variables relacionadas con el transporte multimodal y por carretera y se les ha aplicado un porcentaje para cada una de las variables, indicado mediante un peso.

Cada parámetro ha sido un proyecto individual con sus propios resultados. Toda la información recogida de cada proyecto individual se ha unificado en una evaluación final. En una tercera fase, se han obtenido los resultados preliminares del algoritmo definido previamente.

RESULTADOS

Se ha establecido un sistema de porcentaje considerando cada una de las siete variables. El peso de cada una de las variables es calculado en base a diferentes perspectivas. Se han valorado las siguientes hipótesis:

— Punto de vista del transportista/cliente
— Punto de vista del transporte en general

Considerando las hipótesis y realizando una comparación con el escenario actual del tráfico por Transporte Marítimo de Corta Distancia, se han obtenido las siguientes rutas como las más viables para el trasvase de mercancía de la carretera al mar:

CONCLUSIONES

El modelo de pesos y las hipótesis han sido aplicados a las 15 rutas posibles. Se han identificado 5 rutas viables y el potencial para evitar los problemas del transporte por carretera y el trasvase de mercancías de la carretera al mar, permitirá más integración de la economía entre las regiones de costa Española y Europa. Los resultados suponen un punto de partida para la posible creación de nuevas líneas regulares del Transporte Marítimo de Corta Distancia.

España es un país periférico que hace del transporte marítimo de corta distancia una opción viable para evitar la congestión de las carreteras. También debería contribuir a la limitación de saturación de las rutas de transporte principales y asimismo, preservaría al medioambiente.

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COST STRUCTURE IN A SHORT SEA SHIPPING LINE

S. Saurí[1]

ABSTRACT

Several years ago the Public Administration, especially the European Union, has been promoting the implementation of the Short Sea Shipping (SSS), basically due to both the necessity to reduce the road goods transport (the congestion of the road could be an important problem in the near future) and the positive environmental effects of using the maritime transport instead of road ways. A combination of road and maritime transport in a logistic chain is the main issue. The aim of this article is to analyze the power of the SSS studying two main aspects related to it: cost of port operations and the ship's economies of scale. For this, an expression of generalized cost of transport considering maritime transport is developed, which is compared to the cost of a logistic chain without utilizing the ship. Port operations and shipping cost are included in the model. The expressions are applied to a numerical case. The works permit analyzing the influence of the variables which have a relevant role in the election of the transport supply chain. In this way the main aspects to improve the maritime transport can be identified.

Key words: Short Sea Shipping, Maritime Economy, Supply Chain

INTRODUCTION

At this moment one of the most important problems in the European Policy transport is the high level of traffic roads and the directly associated problems, which

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are basically congestion and pollution. In Spain, additionally, the strong road congestion in the Pyrenees increases the problem, which could be a bottleneck of the freight transport in the near future.

In this context, the maritime traffic is seen as a valid solution to the problem, especially the Short Sea Shipping (SSS). This type of maritime transport can be defined as the freight and passenger maritime transportation taking place in the European ports or between European ports and ports situated in the vicinity of Europe.

When the possibilities of the SSS are analyzed, several factors are usually pointed out. One of which is the economies of scale in ship, as a way to reduce transportation unitary cost; otherwise, port productivity and port costs are usually argued as problems in developing SSS.

According to this, the aim of this article is to quantify the influence these factors have in the total logistic cost in a particular type of a supply chain.

This article is structured in four parts. In the following section, the basic model is explained, using the second part to develop a mathematical model to calculate logistic costs. In the third part, this model is applied in a particular case, achieving some numerical results. The final section describes the conclusions.

THE BASIC MODEL

According to the aim described above, the study of the influence of the economies of scale in ships and port productivity is reduced to a particular case in order to achieve results as accurately as possible. Particularly, a supply basic chain of a company consists on distributing a homogeneous product to several consumers from its factory, distributed uniformly in a region. It is also considered that the product value is not high.

The company has basically two distribution strategies of the product, as showed in figure 1:

a) One-to-many. Each customer receives directly the product from the factory. It is not necessary that each truck service one customer. When particular schedule is not imposed and the value of the product is not high it is possible that all truck are filled and serve several customers in one trip, in order to reduce the total logistic cost. This is case A of figure 1.

b) One-to-many with transshipment. There is a terminal that receives the trucks from the factory and sent other truck to the customers. Few truck of great capacity can supply the terminal every day and from it several vans, which capacity could be a half of first one for instance, can supply the customers, implying a reduction of the transport cost. The final customers receives the same quality services as the first strategy, with a fewer transport cost but the holding and the handling costs of the terminal increase.

This strategy could be cheaper than the first depending on several factors, such as the length between origin and destination or the demand. Each case should be studied separately.

As the same as the first strategy, this basic structure can be optimized: in case the vans can be full, it's possible that in the same trip several customers are served, reducing the transportation cost.

Our problem is focused on companies for which the second strategy to distribute its product is the optimal. Also, it's assumed that there isn't any problem to consider that each van departs full from the terminal and serves several customers, as it is showed in the case B of the figure 1. This consideration is valid particularly if a long distance is supposed from the terminal to the final customer.

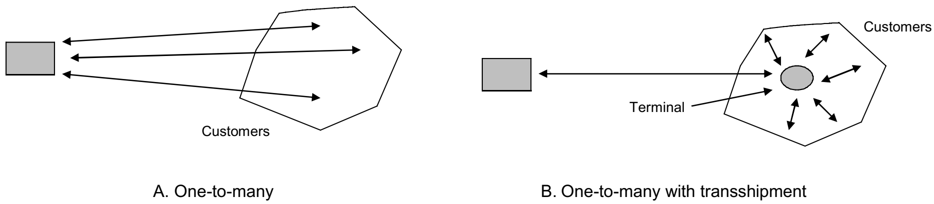

Figure 1. Strategies to distribute a product.

In this context, it is logical that the company analyses another way to transport its product, using the SSS. As a first approximation, when the most economical supply chain of a company is using a consolidation terminal, in the terms exposed in figure 2, the part of the maritime transport, particularly port B, could be viewed in the supply chain the same role as the terminal had when all transport is done only by road transport, as it is showed schematically in figure 2.

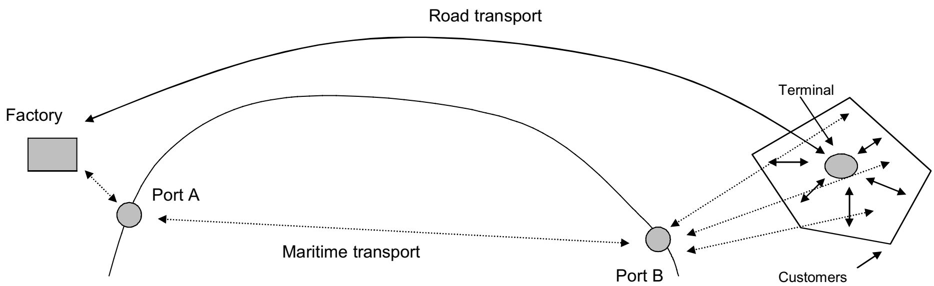

Figure 2. The implementation of SSS compared with road transport.

This alternative way of product distribution, whit maritime transport, in the exposed terms is the base of our study to analyze the SSS.

Focusing on costs, the SSS alternative could be better than only road transport depending basically on maritime cost and port costs, both of which are essentially due to economies of scale in ships and maritime time and operational cost and port productivity respectively. Maritime time and port operational cost are highly difficult to be competitive in respect to the road, because at these moments the usual speeds achieved on roads are higher than the ships and the port labor, port taxes, port congestion, etc make likely port operational cost to be most important than all cost associated to the consolidation terminal. Consequently, the competitiveness of SSS is based essentially on the economies of scale in ship and port productivity, which is analyzed.

It is considered the case that the distance between port B and final customer is not so large that the positive influence of these two factors in cost will be minimal. The weight of ship's economies of scale and port productivity in reducing cost is inversely proportional to the ratio road trip per maritime trip.

THE MATHEMATICAL MODEL

The model of the supply chain showed in figure 2 can be divided into three basic parts (factory to access port A, port A and B and maritime transport and access of port B to final customers), all of which is studied separately.

To calculate the total logistic cost per item a curve between numbers of items versus time is considered (figure 3). This permits analyzing the queue systems generated in the supply chain and then quantifying the holding and inventory cost associated with them.

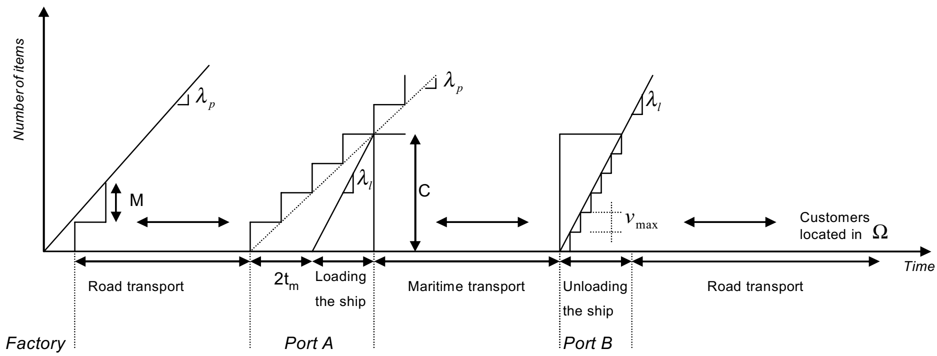

Figure 3. Basic phases of the supply chain considered, including the queue systems generated in factory, port A and port B.

The basic hypotheses are:

— The final customers are located in a region Ω in which the demand is uniformly distributed with rate δ customers per area.

— The company produces with a constant rate λ_p, items per time.
— The loading and unloading port operations rate is λ_l, in terms of items per time.
— There are several trucks with the maximum capacity (M) as possible and completely filled that are constantly carrying on from the factory to the port A, including the time that the ship is not in the port.
— Some vans depart from port B to final customer, each of which serves a particular subregion of demand (Ω_i , where $\sum_i \Omega_i = \Omega$). All vans are full and with a capacity (v_{max}) enough to serve all customer located in Ω_i.
— The ship only serve the same company and its capacity (C) is one that all the items accumulated when the ship is outside of port A and when it is loading can be transported. For this it is also necessary supposing that $\lambda_l \succ \lambda_p$. The ship departs from port A, arrives at port B and return to port A to carry on new products.
— In order to make calculations easier, it is supposed that $C/M \approx \delta$ and $C/v_{\max} \approx \eta$, where δ and η are enter numbers. Thus, the relationcan $\eta \approx \frac{\delta M}{v_{\max}}$ be automatically obtained.

In these conditions, the total logistic cost per item due to the transport from the origin to the port A access (z_{OA}) is the sum of the fixed inventory time and transport cost per dispatch, that is:

$$z_{OA} = \alpha_o + \frac{\alpha_1}{M} = c_i\left(\frac{r_{OA}}{s} + \frac{M}{2\lambda_p}\right) + \frac{2r_{OA}c_d}{M}$$

where:
α_0: fixed inventory cost, due to transport and queue in the factory.
α_1 : transport cost per dispatch.
c_i : inventory cost per item-day.
r_{OA}: road distance from the factory to the port A access.
c_d: transport cost per vehicle-mile.

Additionally, the total logistic cost per item generated from the port A access to the port B exit (z_{AB}) is basically due to unloading and loading port operations (other type of port costs like taxes are included in this concept), inventory cost and maritime transport cost. In mathematical terms it means:

$$z_{AB} = \alpha_3 + 2\alpha_4 C + \alpha_5 + \alpha_6 C = \left(2t_m + \frac{C}{\lambda_l}\right) - \frac{M(\delta - 1)}{2\lambda_p} + \frac{\eta v_{\max}}{\lambda_l} - \frac{v_{\max}^2 \eta(\eta - 1)}{2C\lambda_l} + 2c_o C + c_{sf} + c_{sv} t_m$$

where:
α_3: inventory cost when the freight is in ports in €/day-item.
α_4: unloading / loading port cost in €/item.
α_5: shipping fixed cost per item, in €/item.
α_6: variable shipping cost per item, in terms of €/item-day.
c_o: port operational cost, in €/item.
c_{sf}: fixed shipping cost, in €.
c_{sv}: variable shipping cost, in terms of €/item-navigation day.
t_m: time in ship.
$v_{\max}$: delivery lot size to a customer, that is equivalent to the vehicle capacity (in terms of numbers of items).

The inventory cost due to the port time in both ports is calculated considering the queue systems created in ports (figure 3) and estimating the average time of a item in the system dividing the total area defined by the queue system and the total items in this system (C in both cases).

Finally, to obtain the total logistic cost per item, the supply chain's cost (z_{BF}) from the port B to the final costumers should be characterized. At this part of the trip there is only one origin (port B) and several consumer that are uniformly distributed in a region Ω. We have several vans each of them serves a particular subregion (Ω_i) in this way: it departs from port B and goes full to its region stopping in each customer. The total demand of the customers of each subregion is equivalent to the van capacity, as it is described in figure 4.

In Daganzo (1996) a logistic cost per item for this particular case is studied, using the continuous approximation method. The cost function per item of each van which serves a subregion Ω_i is:

$$z_{BF} = \alpha_7 + \frac{\alpha_8}{n_s v_{\max}} + \frac{\alpha_9}{v_{\max}} + \alpha_{10} n_s = \frac{c_i r_{AF}}{s_{BF}} + \frac{2 r_{BF} c_d}{n_s v_{\max}} + \frac{c_d k \delta^{-0,5}}{v_{\max}} + \frac{c_i k \delta^{-0,5}}{2 s_{BF}} n_s$$

where:
α_7: fixed pipeline inventory cost generated by the trip between port B and the customers.
α_8: transport cost per dispatch.
α_9: transport cost added by a customer detour.
α_{10}: pipeline inventory cost added per item caused by a customer detour.
n_s: number of stops per tour.
r_{BF}: average distance from port B to the points in a delivery region Ω_i.
s_{BF}: representative vehicle speed from B to a region Ω_i.
k: dimensionless factor for VRP local distance.
δ: customers/area.

In each part of the supply chain, there are other types of costs, such as fixed cost of a vehicle stop, but here the basic costs are only considered to make the analysis of the results easier.

Finally, the total logistic cost per item (z_{OF}) when the SSS is used can be modeled by the sum of the three last terms of cost:

$$z_{OF} = z_{OA} + z_{AB} + z_{BF}$$

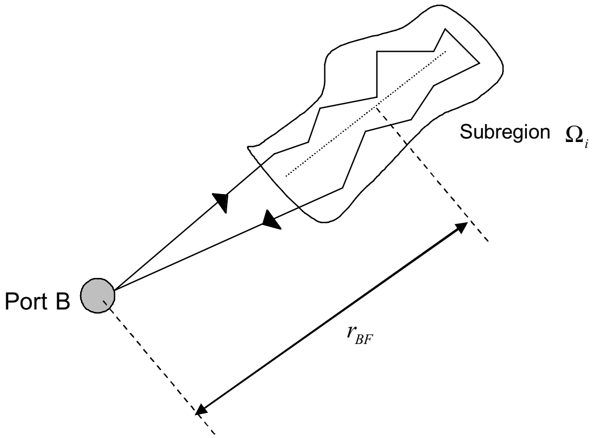

Figure 4. Route from port B to customers situated in subregion Ω_i.

Using this expression is possible to analyze the influence of the economies of scale in ships and unloading and loading port productivity in the total logistic cost per item, which permits evaluating the role of these two factors in competition of SSS in respect to road transport.

A valid way to do so is obtaining the variation of the total logistic cost per item when the port operational productivity (λ_l) and the representative variables of ship's economies of scale (c_{sf} and C) change. Considering a particular trip, the average shipping transport cost, in €/item, is the ratio between the total shipping cost (the sum of fixed, CT_{sf}, and variable costs, CT_{sv}) and the total transported items (the ship capacity in studied case). In case of increasing ship capacity (C), the average cost will reduce basically due to the importance of CT_{sf} in front of CT_{sv}, so that the ship's economies of scale is essentially represented by the variations of the value of fixed shipping cost per item (c_{sf}) and ship capacity (C).

It is important to remark that in a competitive situation a growth of productivity implies a reduction of cost production. However, in case of port industry, due to the present regulation and monopolies, it is difficult that an increasing of port productivity generates directly lower port cost. Consequently, in our analysis the port operational cost (c_o) is considered constant, independent of port productivity increase.

If $z_{OF}(C, c_{sf})$ and $z_{OF}(\lambda_l)$ represent the total logistic cost per item when only the ship's economies of scale and port operational productivity change respectively, the following elasticities are defined to study the influence of two factors in the logistic total cost:

$$\varepsilon_C^Z = \frac{z_{OF}(C, c_{sf}) - z_{OF}^*}{\Delta C} \frac{C^*}{z_{OF}^*} \quad \text{and} \quad \varepsilon_\lambda^Z = \frac{z_{OF}(\lambda_l) - z_{OF}^*}{\Delta \lambda_l} \frac{\lambda_l^*}{z_{OF}^*}$$

Where z^*_{OF} is the logistic total cost per item in the initially considered value of variables.

A NUMERICAL CASE

In this section the total logistic cost per item is obtained in a particular case. It is supposed a factory situated 2 miles far from port A. The freight is loaded in a ship and one day of navigation to arrive at port B is necessary. The distance between port B and a group of customers served by each van is about 5 miles.

The other variables' values are showed in table 1. These values permit obtaining the total logistic cost per item substituting in expression of z_{OF}. This cost is 661€/item.

Variable	Value	Units	Variable	Value	Units
c_{mf}	400	€/item	r_{OA}	2	miles
c_{mv}	50	€/item-day	t_s	0,5	hr
c_i	1	€/item-hr	c_d	15	€/veh-mile
C	500	items	c_s	120	€/vehicle
tm	1	day	k	1,15	
co	70	€/item	δ	0,5	Customers/ miles^2
λ_l	15	items/hr	s_{BF}	80	km/hr
λ_p	10	items/hr	r_{BF}	5	miles
M	50	items	s_{OB}	90	km/hr
η	16,67		v_{max}	30	items
δ	10				

Table 1. Supposed values of the variables.

The next step is evaluating the variation of this total logistic cost, using the concept of elasticity expressed above, when both the ship capacity (C and c_{sf}) and port productivity (λ_l) increase.

— If the value of λ_l goes and to 15 items/hr to 26 items/hr and the rest of the variables' values remain equally, the costs and elasticities showed in table 2 and figure 5 will be obtained. The following conclusions are derived from the results:

— To reduce the logistic cost per item an important way to do it is increasing the port productivity.

— The elasticity's values are lower than one, so the growth of port productivity is higher than the cost reduction.

— The non linear shape of the curve is due to the influence of port productivity in the inventory cost dividing the other factors, as it can be seen in expression of z_{AB}.

— In case of port industry would be completely competitive, a growth in port productivity implies a reduction also of port cost. For instance, if an increase of one unit port productivity, in items per hour, induces a reduction of port operational unitary cost (c_o) in a 5%, the reduction of total logistic cost will be higher as it is showed in figure 5 and in table 2. The elasticity is three and four times better than in case of only port productivity changes.

— Because port productivity affects basically the inventory cost in ports, the growth of port productivity is proportional to unitary inventory cost (c_i).

Increasing only of port productivity			Increasing of port productivity and decreasing port cost			
λ_1	z_{OF}	Elasticity	c_o	λ_1	z_{OF}	Elasticity
15	661		70,0	15	661	
16	658	-0,078	66,5	16	651	-0,250
17	655	-0,073	63,2	17	641	-0,251
18	653	-0,069	60,0	18	633	-0,251
19	650	-0,065	57,0	19	624	-0,251
20	648	-0,062	54,2	20	617	-0,250
21	646	-0,059	51,5	21	609	-0,249
22	645	-0,056	48,9	22	603	-0,248
23	643	-0,054	46,4	23	596	-0,247
24	642	-0,052	44,1	24	590	-0,245
25	641	-0,050	41,9	25	584	-0,243
26	639	-0,048	39,8	26	579	-0,241

Table 2. Total logistic cost per item in case of increasing only port productivity and increasing port productivity and reduction of port cost.

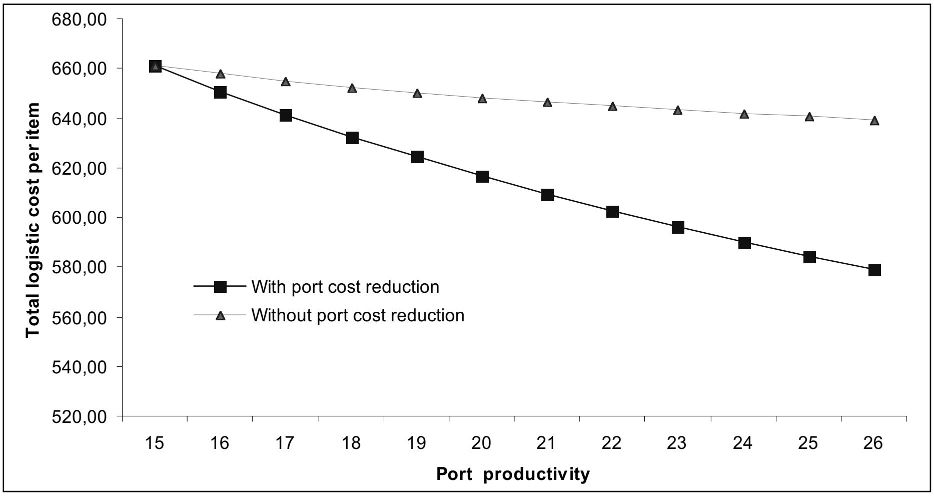

Figure 5. Curve of total logistic cost per item with respect to port productivity.

In case of variation of ship capacity, fixed unitary shipping cost (c_{sf}) and ship capacity (C) may change. At this point, a correlation between the variations of both variables has to be made. The unitary fixed shipping cost, in € per item, is the ratio between the total fixed cost (CT_{sf}) and the ship capacity, so when the second value changes the variations of c_{sf} will be about:

$$\frac{dc_{sf}}{dC} = \frac{d}{dC}\left(\frac{CT_{sf}}{C}\right) = \frac{-CT_{sf}}{C^2} \Rightarrow \Delta c_{sf} \approx \frac{-CT_{sf}}{C^2}\Delta C$$

In this relations between the variation of both variables it is supposed that the total fixed shipping cost and the variable shipping cost (c_{sv}) are approximately constant. Using this last expression the new values of the total logistic cost per item are calculated whilst ship capacity is increasing, as it is showed in figure 6. Also the elasticity of the logistic cost in respect to shipping cost is obtained. The following remarks can be pointed out:

— Increasing the ship capacity, it is possible achieving important reductions of logistic cost per item.
— These reductions are decreasing constantly when the ship capacity growths.
— The elasticity of logistic cost in respect to ship capacity is lower than unity, so if the ship capacity increases one unit, the reduction of logistic cost will be lower than the unity.
— The values of this elasticity is higher than the elasticity of logistic cost with respect to port productivity, which implies that the logistic total cost per item can be reduced more increasing ship capacity than growths of port productivity. However, both factors are strongly important to achieve the competitiveness of SSS in respect to road transport.

c_{sf}	C	z_{OF}	Elasticity z_{OF} -C
400	500	661	
367	550	630	-0,53
337	605	603	-0,50
309	666	578	-0,47
283	732	556	-0,44
260	805	536	-0,41
238	886	519	-0,37
219	974	503	-0,33
201	1072	490	-0,30

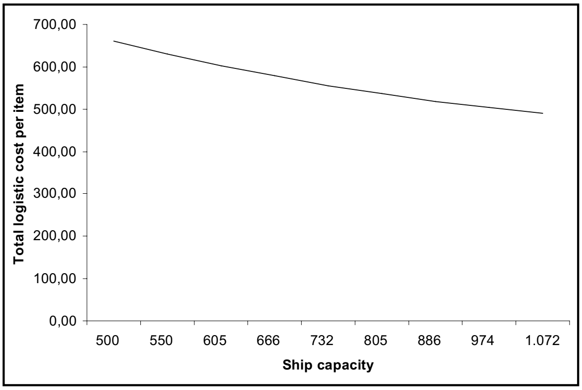

Figure 6. Variation of total logistic cost when ship capacity increases.

CONCLUSIONS

The following conclusions are derived in this article:

— In this article it is considered a supply chain in which a consolidation terminal is optimal in case of only road transport. In this situation, possibility to use maritime transport as an alternative way can be analyzed, considering that ports could have the same role as the consolidation terminal has in the first transport alternative.

— In the implementation of maritime transport in the supply chain there are two factors important: economies of scale in ships and port productivity. The port cost is also essential, but at this moment port industry has strong restrictions to competition so that constant port cost is supposed.

— A mathematical model has been developed to achieve the total logistic cost per item depending on the value of the most significant variables of the considered supply chain.

— In the numerical case, the elasticity of total logistic cost per item in respect to ship capacity is lower than one. Consequently, in case of increasing the ship capacity with one unit, the reduction of logistic cost is lower than one.

— Also, in case of increasing port productivity, a reduction of logistic cost is achieved, with elasticity lower than one, which could be increased if port cost is also reduced.

— The reduction of logistic total cost will be better if the ship capacity increases instead of growth of port productivity.

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ESTRUCTURA DE COSTES DE UNA LÍNEA DE TRANSPORTE MARÍTIMO DE CORTA DISTANCIA

RESUMEN

Desde hace algunos años la Administración Pública, incluyendo la Comunidad Europea, está promocionando el Transporte Marítimo a Corta Distancia (TMCD), motivada esencialmente por la necesidad de reducir el transporte de mercancías por carretera (los costes asociados a la congestión suponen un importante problema a efectos de bienestar social) y por los efectos positivos en términos de costes sociales y ambientales que implica sustituir los tráficos por carretera por vía marítima. Con el TMCD se trata de combinar transporte por mar y por carretera. El objetivo del presente artículo es analizar el potencial de esta combinación modal centrando los trabajos en dos aspectos: la productividad de las operaciones portuarias y las economías de escala del buque, elementos estos que tradicionalmente se han considerado básicos para el desarrollo del TMCD. Para ello se ha calculado el coste total de una cadena logística formada por transporte por carretera y por mar y se ha comparado con el caso de utilizar sólo la carretera. El modelo se ha aplicado a un caso numérico.

METODOLOGÍA

En consonancia con el objetivo del artículo, los trabajos se han centrado básicamente en la obtención de un modelo del coste total unitario del transporte de mercancías en dos casos: suponiendo una cadena logística formada íntegramente por el transporte por carretera; y otra que combina buque y camión. En ambas situaciones se ha supuesto el caso particular de una fabrica que distribuye sus mercancías (*one-to-many*). Respecto al segundo de estas cadenas, se ha considerado que el volumen de transporte y la distancia entre el origen y los destinos son tales que para la empresa resulta más rentable adoptar una configuración de red con terminal de consolidación (*one-to-many with transshipment*); para lo cual los puertos de origen y destino y el transporte marítimo se han concebido como la terminal de consolidación.

Entre los cálculos de los costes conviene destacar los derivados del tiempo, para los cuales se ha estimado las colas formadas en los puertos, y las distancias de reparto del puerto destino a los destinos finales.

A partir de la construcción del modelo de costes de ambas cadenas logísticas, éste ha sido aplicado a una situación hipotética.

A efectos de cuantificar la influencia de las economías de escala del buque y la productividad de las operaciones portuarias en el potencial del TMCD sobre el transporte único por carretera, se ha valorado la elasticidad coste total unitario respecto a la capacidad del buque y a la productividad de las operaciones portuarias respectivamente.

RESULTADOS

En el caso de los costes portuarios, se han obtenidos unas elasticidades coste total unitario-productividad portuaria menores que uno, pero que en términos absolutos suponen una importante reducción de los costes por TMCD. Este efecto positivo puede verse incrementado en caso de una situación de plena competencia de la industria portuaria, en la que cualquier incremento de productividad, y por ende de los costes operativos, los traslada a la tarifa cobrada al usuario final del puerto.

En el caso de los incrementos de la capacidad del buque, hay que tener presente que, al propio tiempo, por las economías de escala, se produce una reducción del coste unitario del transporte marítimo. A tenor de los resultados obtenidos en el caso supuesto, las reducciones del coste total unitario del TMCD a medida que la capacidad del buque es mayor son significativas, superiores al caso anterior, aunque con elasticidades menores a uno.

CONCLUSIONES

Las principales conclusiones son:

— En este artículo se ha considerado el caso de dos cadenas logísticas de distribución de la mercancía de una fábrica a varios destinos: suponiendo transporte únicamente por carretera y combinando carretera y buque. Se ha supuesto una configuración de red logística de *one-to-many* con terminal de consolidación.

— En el desarrollo del TMCD hay dos aspectos que tiene un papel esencial: la productividad portuaria y las economías de escala de los buques.

— Se ha desarrollado un modelo de costes para ambas cadenas logísticas que permita evaluar la variación del coste total unitario con las variables que caracterizan los dos factores del punto anterior.

— Se ha supuesto un caso particular, de donde se ha obtenido que la elasticidad del coste total unitario respecto a la productividad portuaria es negativa y menor que uno, aunque las reducciones del coste unitario en términos absolutos son significativas.

— En caso de la elasticidad del coste total unitario respecto a la capacidad de la terminal, se obtienen valores negativos y menores que uno, aunque mayores que con la productividad portuaria. Esto es, con incrementos de la capacidad del buque es más competitivo el TMCD respecto a la carretera que con mejores de la productividad portuaria.

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LEISURE PORTS PLANNING

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ABSTRACT

Leisure ports constitute a separately identifiable leisure option which is normally associated with Maritime Tourism. They form a highly dynamic sector whose expansion has knock-on effects, both direct and indirect, on numerous economic activities. The lack of foresight in the development of leisure ports and indiscriminate local actions aimed at solving the problem of the increase in maritime recreational activity may lead to an irreversible deterioration in the coastal environment in which this activity takes place. An awareness of the gravity of this threat led the Regional Government of the Autonomous Community of Cantabria (Spain) to reflect on several important points: Which are the key factors to take into account when establishing a non-speculative ports policy which respects the coastal environment? How could the degradation of the coastal strip be avoided while, at the same time, the real needs of the region are satisfied? The aim of the present paper is to evaluate the magnitude and economics importance of the recreational fleet, considering these as decisive aspects in the planning decisions finally adopted.

Key words: Planning leisure seaports; Impact of the recreational fleet; Regional Input-Output analysis.

BACKGROUND

In Spain, the construction and exploitation of leisure ports is undertaken through private initiative upon the concession of the corresponding government authority. Thus, the general port development of a region is a consequence of a set of

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individual concessions. It would seem clear, therefore, that the key to a possible planned development of leisure ports lies in the control of the concession granting process. But who grants these concessions?

The current configuration of the Spanish State of Autonomous Communities, consecrated in the Constitution of 1978, establishes the exclusive competence of the State in commercial ports of general public interest and the competence of the Autonomous Communities in leisure[2]. Although this arrangement might seem at first sight simple, the practical consequences of this separation in the Constitution are not so explicit. The concessions for the construction of leisure ports in coastal areas under the ownership of the commercial ports of general interest are granted by the Port Authorities. Both the ports and the port authorities form part of the Spanish State ownership ports programme[3]. However, since 1997 these ports have been at the service of regional economic development and their governing bodies are designated by the Autonomous Communities[4].

Leisure ports built in other ports of non-general interest or in any other area of the region require the concession of the corresponding Autonomous Community. These ports make up the regional ports system to be analysed[5] (See Figure 1).

In keeping with the above, it can be stated that there is a form of direct or indirect control by the Autonomous Community over the granting of concessions for building leisure ports in the region. Thus, the governments of the Spanish autonomous communities have sufficient mechanisms at their disposal to be able to develop a regional ports programme. But what really happens in practice? There are, in fact, two clearly identifiable situations.

The first is a completely unplanned regional ports development, in which ports are built in response to the initiatives of constructors and developers. After designing a basic project, these constructors or developers initiate a series of proce-

2 The Spanish Constitution, in its article 148, establishes that the Autonomous Communities can assume the competence in matters of ports of shelter, leisure ports and any ports which do not undertake any commercial activity. The Statute of Autonomy of Cantabria, meanwhile, stipulates, in its article 22.6, that the exclusive competence in matters of ports of shelter, leisure ports and any ports which do not undertake any commercial activity corresponds to the Regional Government of Cantabria.

3 The Spanish ports system is made up of 45 greatly varied ports of general interest (commercial ports under State ownership) run by 27 Port Authorities which are co-ordinated by the National Ports Office.

4 Due to the economic and social impact that the ports of general interest have for the Autonomous Communities and given the new territorial organisation of the Spanish State, it would seem appropriate that these should have a greater say in the decisions taken by the Port Authorities, in order to integrate more effectively the economic and territorial interests of the Autonomous Communities affected. To this end, the Ports Law of 1997 established that the Autonomous Communities should designate the president of this organism and determine the final composition of its governing board.

5 Since 1982 the Regional Government of Cantabria has control over the Santander Ports Group composed of the ports of Castro Urdiales with the port installations of Saltacaballos, Ontón and Mioño, Laredo, Colindres, Santoña with its insatallations at Quejo, Suances with its installations in the estuary, Comillas and San Vicente de la Barquera with its installations at Unquera.

dures which may last for several years, in which the main obstacle is that of the "declaration of environmental impact" issued by the Ministry of The Environment, after countless enquiries to different organisms and organisations. Finally, if the responses are all positive, the concession is granted for a maximum period of 30 years in exchange for the payment of two canons (for occupation and exploitation).

The second situation is one of a planned regional ports development which responds to public initiative. In these cases, all of the procedures involved are usually undertaken by the regional Department which has established the plan. Once all of the problems are solved, this department will grant the concessions to promoters in view of criteria of publicity and transparency. The system is really a mixed one combining both private and public initiative.

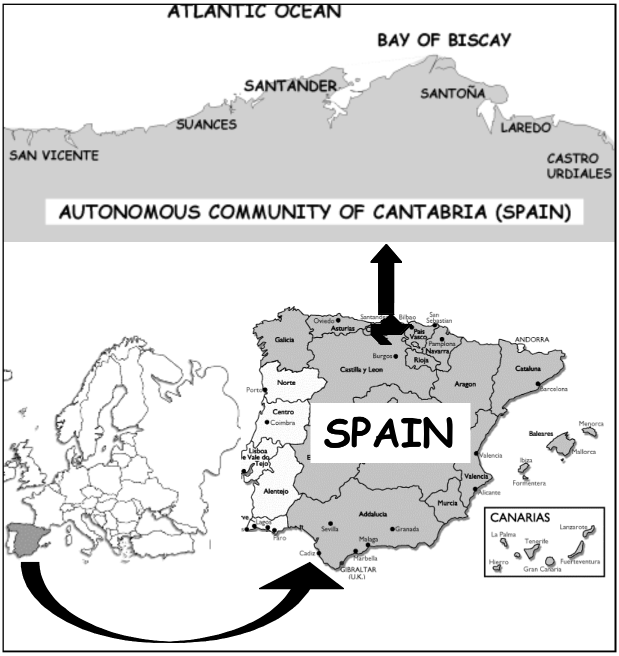

Figure 1: Map of locations of main seaports of the Autonomous Community of Cantabria

In 1999, with all of this in mind, the Ports Council of The Autonomous Government of Cantabria (Spain) decided that the time had come to provide a solution to the serious problems facing the region's recreational fleet. The demand for the building of leisure ports was increasing. There were a number of different private and/or municipal projects on the negotiating table, leading the politicians to reflect on whether it was advisable to look ahead and plan the future of the region's maritime leisure installations and whether the lack of such a plan might not lead to an irreversible deterioration in the coastal environment. They came to the conclusion that a regional ports policy was required. The main consideration in the design of these recreational port installations had to be the type of craft using them. The idea was not to pepper the coast with countless leisure ports in the style of "residential ports". The aim was rather to accommodate a recreational fleet which suffered from rather poor mooring facilities and a lack of suitable installations - a situation which might, unless modified, cause a certain degree of damage to the coastal area. Thus, the Autonomous Government of Cantabria began to set up several studies to enable them to estimate the real regional demand for leisure ports in relation to the present and future magnitude of the recreational fleet.

They also felt that the time was right to determine the economic importance of the sector for the region. There already existed certain widely accepted reasons for studying the "qualitative importance" of the maritime recreational sector. This sector is, of course, one which is deeply rooted in the seafaring tradition of the region. Moreover, the area of the coast from which maritime activities can be practised is indeed extensive. These factors contributed to the sustained expansion of the fleet. However, certain other factors of a more "quantitative" nature were also required in order to determine the economic importance of the recreational fleet in Cantabria.

Finally, it was felt that both the physical and economic importance of the fleet should be decisive factors in the definition of the leisure ports planning and development policy. Thus, the Regional Authorities, as well as accessing information on the real need for berths, could also assess the impact that the activity of the recreational maritime fleet might have on the rest of the regional economy.

In keeping with the above, the present work is developed under the hypothesis that the arguments outlined above will be the ones used by the relevant political bodies in Cantabria to enact a regional leisure ports plan. Our aims are thus twofold: first, to determine the size of the recreational fleet; and second, to evaluate the macroeconomic impact that this activity has on the regional Gross Operating Surplus (GOS) and Employees' Salaries (ES).

METHODOLOGY

This section outlines the instruments which form the basis of the methodology used to determine the present and future magnitude of the fleet and its impact on the rest of the economic sectors of the regional economy of Cantabria. On the one hand, an in-depth knowledge of the fleet is essential in order to be able to develop a regional ports plan responding to real needs. Secondly, an in-depth knowledge of the socio-economic effects of the sector on the region will serve as an argument for, or against, the political decision to develop such a plan.

We shall thus outline below the set of techniques and methods used in the elaboration of the census of the recreational fleet of Cantabria, in the prediction of the future of the fleet and in the determination of the effects of the sector on the regional economy.

The Census of Recreational Craft

One of the main aims of the present work was to verify the exact magnitude of the recreational fleet of the Autonomous Community of Cantabria. The lack of any data on this sector led us to devise a census of the region's craft. (CERCAN-98). The following stages of the work were established: 1) Definition of the computing tool, design and elaboration of a data base which would permit the future storage and treatment of the data. 2) Enquiries and Data gathering from the registers; and 3) Data Processing.

The census was to gather data pertaining to the fleet units in active use inscribed in any of the six registers existing in the region's ports: Castro Urdiales, Laredo, Santoña, Santander, Requejada (Suances), and San Vicente de la Barquera. Among the variables used to define the characteristics of the craft, the most important, apart from those incorporated for the purposes of control, are the length, age, type of craft, material of hull, country of construction and residence of owner. This meant the gathering and processing of more than 100,000 fields in a data-base.

Fleet Prediction Process

In order to carry out the predictions of the number and GRT of the fleet, ARIMA time series models were constructed. These models have been estimated both for the six above-mentioned regional registers and for the whole of Cantabria.

The annual historic series of the fleet had to be elaborated from data obtained directly from the various registers of Cantabria, as there are no figures published on this area. The first craft registered in Castro Urdiales dates from 1907, in Santander 1914, in Santoña 1924, in Laredo 1943, in Requejeda 1952 and in San Vicente de la Barquera 1969. Thus, in order to contemplate the same time scale for all the series considered, annual data were used from 1960 to 1998 (39 observations per series). Predictions have been made from 1999 to the year 2005.

ARIMA processes are used for the explanation and prediction of time series through the use of the history of the series itself as the single source of information. Predictions are based on the central hypothesis that future conditions will be similar to those of the past. These models are particularly useful for short and medium term prediction.

The elaboration of an ARIMA model is carried out using the so-called Box and Jenkins method (1976), by means of the following stages: identification of the model, estimation of parameters, diagnosis of results and, finally, the predictions. In this sense we should point out the works of Hillmer and Tiao (1982), Madden and Batey (1983), Kohn and Ansley (1986), Findley et al (1998), and Fisher and Planas (1998). For the present paper, slight adjustments have been made to the general ARIMA model (0,2,2). Three measurements have been used to analyse the quality of these adjustments:

In order to study the quality of the adjustments, we have used:

- Mean square root error (MSRE) of each adjusted model.
- The relative percentage error (RPE-1998) for the prediction for the year 1998, that is, the comparison of the last real data available with its corresponding prediction.

Maritime Recreational Sector Multipliers

The determination of the effects of maritime activity on the region's economy constitutes the third objective of the present work. For this purpose it is usual to employ multipliers determined according to criteria of different types. In this sense, some of the most noteworthy works are those of Miyazawa (1968), Blackwell (1978), Batey et al (1987), Duchene (1993), Pulido and Fontela (1993), Otero (1995), Pulido (1996) and Isla (1998). In this study, these values have been obtained using a well-known application of input-output methodology - the demand model. Through this, the impact of the consumption of the maritime recreational sector on the different economic sectors of the region can be calculated. To implement this methodology, the input-output table (IOT) available for Cantabria for 1994 (IOT-CAN-94) has been used and the vector of consumption and investment has been drawn up for the maritime sector. These elements are essential for determining the multipliers which will eventually enable the impact of the maritime sector on the rest of the economy to be quantified. Thus, before turning to the multipliers themselves, let us now focus on the fleet consumption vector. This is the instrument which, together with the IOT, will enable the impact of demand to be determined. This vector is elaborated in three different stages:

1. Elaboration of a questionnaire on the consumption of the maritime recreational sector of Cantabria, through which the average expenditure of craft per items of consumption could be defined (Pérez-Labajos, 2001).
2. Estimation of the consumption and investment of the maritime recreational sector per items of consumption. The projection of this consumption of the craft obtained from the questionnaire onto the real universe allowed us to establish a total expenditure structure per items of consumption for 1998 and, through estimations, the predicted expenditure for 1999. Since the IOT used refers to 1994, we have deflated some consumption vectors to this year. As for the figures on investment in port infrastructures undertaken by the Public Works Department, the figures are for 1998 to 1999, according to the data provided by the Council of Hydraulic Works and Ports (Sarabia et al , 1999).
3. The net consumption vector for the maritime recreational sector per economic sector was estimated. The determination of the total consumption of the maritime recreational sector has been made by imputing the expenditure per items of consumption to the sectors of IOTCAN-94 in keeping with the records of the National Accountancy Office (see Figure 2).

The internal coefficients of the demand of the maritime recreational sector were determined. To do this, the net initial loss consumption of the maritime recreational sector, for each economic sector, was divided by the total consumption of the maritime recreational sector. These coefficients define the vector which determines the direct effects on production.

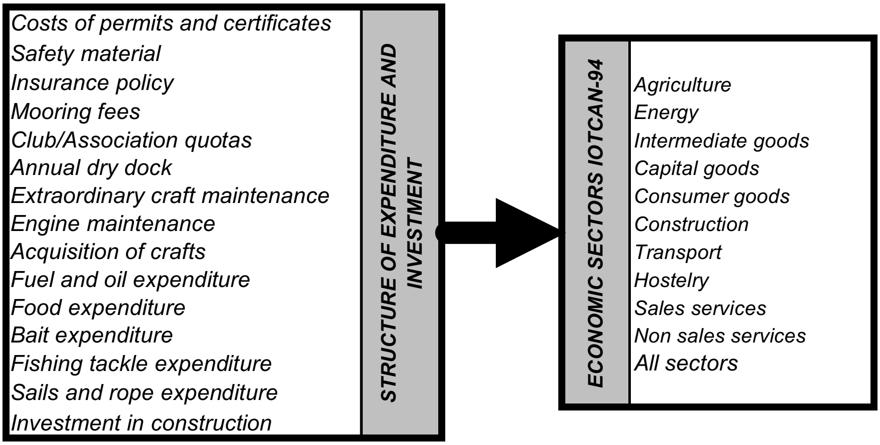

Figure 2: Imputation of Expenditure of Recreational Maritime Fleet of Cantabria per item of consumption to the net sector vector.

As for the multipliers, both internal and total multipliers were estimated. The so-called "internal multipliers", apart from any technological considerations, are those which enable the effective repercussions which an increase in demand from the maritime recreational sector would have on the internal production pattern. Thus, the intermediate consumption imports made by Cantabrian companies function as losses in the multiplier effect.

Multipliers and effects have been determined in absolute values for the GOS and the ES.

To do this, we defined previously the direct effects on internal consumption using the maritime recreational sector consumption vector itself $[RSC^*]$. Net maritime recreational sector consumption is synonymous with direct internal production.

The direct effects on the GOS have been determined by multiplying its coefficients matrix by the net maritime recreational sector consumption vector $[GOS^*][RSC^*]$.

The total effects of the maritime recreational sector on the gross operating surplus were determined by multiplying the direct effects by the Leontief inverse $[GOS^*][I-A]^{-1}[RSC^*]$. As for the indirect effects, these were determined from the difference between the total and the direct effects.

The direct effects on the RA were determined by multiplying its coefficients matrix by the net maritime recreational sector consumption vector $[RA^*][RSC^*]$.

The total effects of the maritime recreational sector on employees' salaries was determined by multiplying the direct effects by the Leontief inverse $[RA^*][I-A]^{-1}[RSC^*]$. As for the indirect effects, these were determined from the difference between the total and the direct effects.

As for the determination of the global multipliers and effects, the structure of impacts on the different magnitudes is similar to that shown by the internal production. The only aspect that changes is the Leontief inverse $[I-A]^{-1}$ which determines the total effects and, as indicated previously, this magnitude is determined from the total intermediate consumption. Thus, the direct effects do not change with respect to those determined internally.

ANALYSIS OF THE SIZE OF THE FLEET

In order to design realistic port developments, it is essential to verify the current and predicted magnitude of the recreational fleet in the Autonomous Community of Cantabria. The balance between the supply of maritime leisure installations and the real demand will allow for a better distribution of resources. Thus, at the end of 1998, the number of berths in the region was 1683.

The present section outlines both the structural analysis of the current situation of the fleet and the results obtained for the prediction of the fleet for the period 1999-2005.

Current situation of fleet

The elaboration of a Census of recreational craft allowed us to set about an in-depth analysis of the fleet, as summarised below.

On December 31st 1998, the Autonomous Community of Cantabria boasted an active registered recreational fleet of 5,301 craft with a total tonnage of 13,588.59 GRT. Taking into account that we are dealing with those craft listed in the harbour master's offices of Cantabria, these must have a length of ≥2.5 metres, as craft of smaller dimensions are not registered here. However, the larger craft, with a length of over ≥4.5 metres, account for 3,549 units with a total capacity of 12,255.2 GRT. Thus, although the structural analysis is focused on this latter section of the fleet, the analysis also takes in certain aspects of craft of less than 4.5 metres in length, since these constitute 1,752 craft with 1,333.35 GRT. The "de facto" fleet reached a total of 5,970 crafts, after adding to those registered in Cantabria around 669 units registerd outside but which remain in the region on a regular basis, mostly belonging to owners resident in Cantabria.

The variables formalised in the aggregate structural analysis presented here are the length, age, type of craft, material of the hull, country of construction and residence of owner. In all cases, we refer both to the number of craft and to the tonnage (GRT).

The *average capacity* of the craft of a length of ≥4.5 metres for all the Autonomous Community is around 3.45 GRT. Only Santander registers a value above this figure with an average capacity per craft of 3.84 GRT. The remaining ports give values below this average, in the following order: Laredo (3.32 GRT), Castro Urdiales (2.56 GRT), Requejeda (2.52 GRT), San Vicente de la Barquera (2.44 GRT) and Santoña (2.09 GRT).

97.33% of all of the registered craft, which means a total of 87.43% of the total GRT, are shorter than 10 metres in length. The two most significant length groups are the ≥5 metres and the <10 metres segments, which together make up 64.78% of the tonnage. The average craft in the Autonomous Community has a length of between 5 and 7 metres.

As regards the *age of the fleet*, 51.25% of the craft and 39.42% of the GRT are less than 10 years old. Moreover, craft of over 20 years of age make up only 31.88% in number and 37.71% in GRT. In general terms, the craft of a smaller length are newer than the larger ones.

Of the 9 existing *types of craft*, only three are relevant, making up, in the section of the fleet with a length of ≥4.5 metres, 82.62% in number and 84.68% in GRT. These are on-board motor craft (53.17% of the fleet and 55.48% of the GRT), outboard motor craft (15.84% in number and 8.93% in GRT) and sailing boats (13.61% in number and 19.29% in GRT).

The *hulls* of the recreational craft of Cantabria are composed of thirteen materials. Most use polyester (47.7% in number and 55.4% in GRT), the next most used material being wood (39.17% in number and 28% in GRT) with plastic in third place (9.24% in number and 11.07% in GRT).

Most of the Cantabrian recreational fleet is of Spanish construction (85.66% of the units, making up 75.6% of the tonnage). Apart from Spain, the leading countries are France (5.8% in number and 10.09% in GRT) and The USA (3.07% in number and 4.96% in GRT).

Although there is a great diversity in the *residences of the owners*, Cantabria is the community in which most of them reside (72.25% in number and 64.52% in GRT), followed in order of importance by The Basque Country, Madrid, Castille-Leon (the latter make up 22.27% in number and 28.2% in GRT).

Another interesting aspect was the location of the craft in the different ports of region. In this analysis, we differentiate between the fleet registered in Cantabria from units under foreign registration. No doubt, this provides some information as to the qualitative aspect of demand.

In early March, 1999, once the task of identifying all of the craft of the Cantabrian fleet (registered units) in the various harbours of the Autonomous Community had been completed, 2,725 units had been located with a total tonnage of 7,691.42 GRT. These figures include craft of a length of ≥2.5 metres and <4.5 metres. Taking into account only those craft of a length of ≥4.5 metres, 1992 craft were identified, totalling 7,120.32 GRT. The differences between the values of the two segments of the fleet and the total figures registered, as indicated above, is accounted for by the craft which are "hibernating" in boathouses or other similar establishments in Cantabria or in other ports and/or places outside the Autonomous Community.

The *outside-registered craft* belong to three different types of owners. Firstly, owners resident in Cantabria, who have acquired their craft in another autonomous community. Bear in mind that even if there is a change in owner, the register is maintained. In order to keep a check on these craft which stay for long periods in a community outside that in which it is registered, the harbour master's offices issue a new sailing licence. Secondly, there are some owners who reside in other Autonomous Communities but use the various mooring and anchoring installations existent in Cantabria as stable base ports. Finally, there are a number of owners from neighbouring communities (The Basque Country and Asturias) who use these installations for short periods.

Future Situation (1999-2005)

The results obtained from the models of prediction of the future of the fleet are shown in Table 1. They refer to the number of crafts and the GRT predicted for the various leisure ports and for the whole of Cantabria, for the years 1999-2005.

Year	Prediction	Seaportts of Cantabria						Total
		Castro	Laredo	Santoña	Santander	Suances	S. Vicente	
1999	Number of craft	356	701	443	3.343	362	294	5.499
2000		365	716	463	3.475	378	302	5.699
2001		373	731	482	3.607	394	310	5.897
2002		382	746	502	3.739	410	318	6.097
2003		390	761	521	3.871	426	326	6.295
2004		399	776	540	4.003	442	334	6.494
2005		407	791	560	4.135	458	342	6.693
1999	GRT	737	1.766	644	9.929	586	431	14.092
2000		758	1.793	665	10.347	586	445	14.594
2001		780	1.820	686	10.764	586	459	15.096
2002		801	1.847	708	11.182	587	472	15.597
2003		823	1.874	729	11.600	587	486	16.099
2004		845	1.901	750	12.017	588	500	16.601
2005		866	1.928	772	12.435	588	514	17.103

Table 1: Annual predictions of the number of recreational crafts and GRT of the Cantabrian Fleet.

The expected growth rates, for most of the period considered, are over 3%. These rates are very similar both in their value and in their tendency, which is slightly on the decrease. If these predictions are fulfilled, then by the end of the period indicated above, 1,193 new units will have been incorporated with a total tonnage of around 3,010 GRT.

As regards the errors in the adjusted models, if we look at the number of crafts for the whole of Cantabria, it can be appreciated that the RECM is 78 units, which means an average error per year of 78 crafts according to the general model. This error is smaller if we consider each port individually: Castro Urdiales 6 crafts, Laredo 15, Santoña 12, Santander 50, Suances 8 and San Vicente de la Barquera 9. Logically, the greatest errors are for the larger ports. The relative percentage error (RPE) for the year 1998 is practically non-existent.

Table 2 contains the errors for the series: number of crafts and number of GRT per port. The RECM for the whole of Cantabria is 154 TRB. The relative percentage errors for 1998 are also insignificant.

Seaports	Number of craft		Number of GRT	
	MSER	RPE(1998)	MSER	RPE(1998)
Castro Urdiales	6,37	-0,57	15,70	-1,05
Laredo	15,04	0,00	40,91	-0,31
Santoña	12,32	0,71	14,80	-0,05
Santander	45,92	0,00	113,69	1,47
Suances	8,44	0,58	11,88	-0,51
San Vicente	8,66	-0,35	11,57	1,71
Total	77,91	0,26	153,69	-1,24

Table 2: Measurement of error of adjusted models.

MSER
= mean square error root

RPE (1998)
= relative percentage error for the year 1998

MACROECONOMIC IMPACTS OF THE MARITIME RECREATIONAL SECTOR

This section presents the results obtained for the impacts, both on the internal production of Cantabria (only that realised by resident companies) and the global production (as well as the internal production, imports are also taken into account). The multipliers have been calculated for the year 1998 and estimated for the year 1999 for the gross operating surplus (GOS) and for employees' salaries (ES).

Internal Production of Cantabria

This item refers to the multipliers determined taking into account the inputs supplied by resident companies. Thus, the multipliers measure the internal economic impact produced by the demand of the maritime recreational sector of Cantabria on the rest of the economic sectors of the region (see Table 3).

The total internal multiplying effect of demand of the maritime recreational sector on the GOS for 1998 is 23.83%. This means that for every $100 of expenditure of the maritime recreational sector, a GOS of $23.83 is generated. The impact of the direct multipliers is 16.95%, while that of the indirect multipliers is 6.89%. In 1999, the total effect is 24.2% (17.24% being direct and 6.9% indirect).

The demand of the maritime recreational sector produced, in 1998, a total internal multiplying effect on ES of 29.04%. This means that for every $100 ptas. of consumption of the sector, $29.04 of ES are generated. The consumption of the maritime recreational sector generated $21.68 directly and $7.35 indirectly. The total multiplier for 1999 is 30.21%, 22.68% corresponding to direct effects and 7.58% to indirect effects.

Table 3. Internal Multipliers of GOS and ES of recreational maritime sector, per sector (1998-1999).

Economics Magnitudes	Year	Effects	Agriculture	Energy	Intermediate goods	Capital goods	Consumer goods	Construction	Transport	Hostelry	Sales services	Non sales services	All sectors
GOS	1998	T	0,0248	0,0084	0,0093	0,0320	0,0087	0,0470	0,0069	0,0157	0,0826	0,0030	0,2383
		D	0,0207	0,0042	0,0000	0,0292	0,0077	0,0460	0,0000	0,0000	0,0614	0,0004	0,1695
		I	0,0041	0,0042	0,0093	0,0029	0,0010	0,0010	0,0069	0,0157	0,0212	0,0026	0,0689
	1999	T	0,0232	0,0080	0,0099	0,0296	0,0083	0,0577	0,0073	0,0151	0,0799	0,0031	0,2420
		D	0,0193	0,0038	0,0000	0,0267	0,0073	0,0567	0,0000	0,0000	0,0582	0,0004	0,1724
		I	0,0039	0,0042	0,0099	0,0029	0,0010	0,0010	0,0073	0,0151	0,0216	0,0027	0,0696
ES	1998	T	0,0036	0,0055	0,0141	0,0971	0,0150	0,0844	0,0045	0,0062	0,0308	0,0292	0,2904
		D	0,0030	0,0027	0,0000	0,0884	0,0132	0,0826	0,0000	0,0000	0,0229	0,0040	0,2168
		I	0,0006	0,0027	0,0141	0,0087	0,0018	0,0018	0,0045	0,0062	0,0079	0,0252	0,0735
	1999	T	0,0034	0,0052	0,0150	0,0899	0,0143	0,1036	0,0048	0,0059	0,0298	0,0303	0,3021
		D	0,0028	0,0025	0,0000	0,0810	0,0126	0,1018	0,0000	0,0000	0,0217	0,0039	0,2263
		I	0,0006	0,0027	0,0150	0,0089	0,0017	0,0018	0,0048	0,0059	0,0081	0,0264	0,0758

T = Total; D = Direct; I = Indirecs

Total Production of Cantabria

This section presents the results obtained from the global multipliers which, unlike the internal ones, take into account the total requirements of intermediate consumption (both that supplied by resident companies and by imports). The structure of the impacts on the various macromagnitudes is similar to that shown for the internal production. Moreover, given that the direct effects are the same as those determined previously by the internal multipliers, we shall refer only to the total and indirect effects (see Table 4).

The total multiplying effect of demand of the maritime recreational sector on the GOS is 35.5%. This means that for every $100 of expenditure of the maritime recreational sector, $35.5 of GOS would be generated. The indirect multiplying effects would be 18.6%. For the year 1999, the total effects reach 35.97% and the indirect effects 18.73%.

The demand of the maritime recreational sector originated in 1998 a total multiplying effect on the ES of 39.74%. Every $100 of consumption of the maritime recreational sector would generate $37.74 in ES. The impact of the indirect multiplying effect would be 18.05%. The effects for the year 1999 would be 41.03% for the total and 18.4% for the indirect multipliers.

Acknowledgements

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Table 4. Totals Multipliers of GOS and ES for recreational maritime sector, per sector (1998-1999).

Economics Magnitudes	Year	Effects	Agriculture	Energy	Intermediate goods	Capital goods	Consumer goods	Construction	Transport	Hostelry	Sales services	Non sales services	All sectors
GOS	1998	T	0,0266	0,0384	0,0255	0,0383	0,0108	0,0475	0,0128	0,0348	0,1157	0,0046	0,3550
		D	0,0207	0,0042	0,0000	0,0292	0,0077	0,0460	0,0000	0,0000	0,0614	0,0004	0,1695
		I	0,0060	0,0343	0,0255	0,0092	0,0031	0,0015	0,0128	0,0348	0,0543	0,0042	0,1856
	1999	T	0,0250	0,0386	0,0268	0,0359	0,0104	0,0582	0,0133	0,0338	0,1132	0,0047	0,3598
		D	0,0193	0,0038	0,0000	0,0267	0,0073	0,0567	0,0000	0,0000	0,0582	0,0004	0,1724
		I	0,0057	0,0348	0,0268	0,0092	0,0031	0,0015	0,0133	0,0338	0,0550	0,0043	0,1873
ES	1998	T	0,0038	0,0250	0,0386	0,1163	0,0186	0,0853	0,0084	0,0137	0,0431	0,0445	0,3974
		D	0,0030	0,0027	0,0000	0,0884	0,0132	0,0826	0,0000	0,0000	0,0229	0,0040	0,2168
		I	0,0009	0,0223	0,0386	0,0279	0,0054	0,0027	0,0084	0,0137	0,0202	0,0405	0,1805
	1999	T	0,0036	0,0251	0,0407	0,1089	0,0179	0,1045	0,0086	0,0133	0,0422	0,0455	0,4103
		D	0,0028	0,0025	0,0000	0,0810	0,0126	0,1018	0,0000	0,0000	0,0217	0,0039	0,2263
		I	0,0008	0,0226	0,0407	0,0279	0,0053	0,0027	0,0086	0,0133	0,0205	0,0416	0,1841

T = Total; D = Direct; I = Indirecs

CONCLUSIONS AND REGIONAL LEISURE PORTS POLICY

Towards the end of 1998 the excess of demand was around 71,8% %, which meant that more than 4000 berths were needed. Moreover, for the period 1999-2005 (both inclusive) a mean annual growth of the fleet of around 200 units and 500 GRT was predicted. This meant an annual growth of over 3% for both items. All of this could lead to a deterioration in the future situation which might take the shape of an uncontrolled increase in the occupation of the harbours.

The economic impact of the maritime recreational sector on the regional economy of the Autonomous Community is increasing, as can be deduced from the evolution of the multipliers estimated for the years 1998 and 1999 for the macro-magnitudes analysed. The "leaks" in the multiplier effect produced by the importing of intermediate consumption by the sector, determined by the differences between the total and the internal multipliers, show a considerable reduction in the GOS (0,33%) and to a greater extent in the EA (1,04%). These reductions bring to light the increasing substitution of imports in the sector due to the greater participation in the activity of resident companies. Both of these increases contribute positively to the regional GAV factor costs (with its various components)

Taking into account the present and future needs of the recreational fleet and its economic importance, the Regional Government of Cantabria resolved to carry out a Regional Programme of Leisure Port Installations, both public and private, a programme which was above any kind of speculative pressure and which respected the coastal environment. Preparatory technical studies were initiated in order to satisfy the great excess of demand for the existing berths. Thus, the construction of several installations was planned for the next few years with a total of 3,293 berths distributed as shown in the Table 5.

Predicted situation of installations	Nº of berths (years 1999-2005)
San Vicente	1.500
Suances	75
Santander (Bahía)	800
Santander to Santoña (Isla y Somo)	218
Santoña	150
Castro Urdiales	550
Total	3.293

Table 5: Developing regional leisure seaports.

LESSONS LEARNED

It would appear to be ever more evident that, in the case of public initiative projects, apart from their economic feasibility, the socioeconomic impacts induced by them should be evaluated. These projects should be presented and accepted not only on a political level but on a social level, too. Thus, any other qualitative or quantitative evaluation, whether or not these are used for the final planning, must be accompanied by an estimation of the socio-economic effects of the project.

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