Vertical integration and exclusivities in maritime freight transport

Óscar Álvarez-SanJaime, Pedro Cantos-Sánchez, Rafael Moner-Colonques, José J. Sempere-Monerris

Abstract
A key recent theme in maritime freight transport is the involvement of shipping lines in terminal management. Such investments are costly but allow liners to provide better service. Most of these new terminals are dedicated terminals but some are non-exclusive and let rivals access them for a fee. In this paper, we show that a shipping line that builds its own terminal finds it strategically profitable (i) to continue routing part of its cargo through the open port facilities, and (ii) to keep its terminal non-exclusive. In this way, the liner investor pushes part of the rival’s freight from the open to the new terminal. Besides, under non-exclusivities, the shipping lines offer a wider variety of services, total freight increases and the resulting equilibrium fares are higher than with a dedicated terminal.

Keywords:
Freight transport
Shipping lines
Vertical integration

1. Introduction

Over the last decades the liner shipping market has witnessed extensive changes both in sea transport and the stevedoring market. The move towards increasingly converging and integrating markets has produced a substantial growth in the scope of activities performed by carriers, in terms of geographic coverage, frequency of services, faster transit time and supply chain management. An increase in the complexity of the maritime logistics chain has indeed occurred. The usual competition between individual shipping companies and between ports has changed to competition between logistics chains (Suykens and Van de Voorde, 1998), basically composed of three large sections: the purely maritime services, the freight handling in the port and the hinterland services. An improved organization of these sections becomes fundamental regarding what “product” is offered by a shipping line at a particular port. A key recent theme is the involvement of shipping companies in terminal management. The objective of our paper is to analyze the derived effects of vertical integration between maritime services and terminal port activities on prices, demand and profits; we wish to assess whether it is strategically profitable for a shipping line to have a dedicated terminal of exclusive use and/or continue to employ the port’s open infrastructure.

The port and maritime industry has recently evolved toward various forms of concentration and cooperation. The main types are horizontal cooperation between shipping companies, horizontal cooperation between terminal operating companies...

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1 We shall refer to open port facilities to mean that any shipping line can access them on equal conditions, regardless of the type of property, be them public or be them independently operated multi-user facilities.

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(TOCs), and vertical cooperation between TOCs and shipping companies (see e.g. Heaver et al., 2001). As a consequence of port reform, and over the last couple of decades there has been a decrease in the number of state-owned terminal facilities. This process of port privatization has led to private investment in container terminals, as a means to overcome shortages in port infrastructures. Mega-vessels cannot be handled at all terminals, thus bringing about a significant increase in stevedoring costs, and the loading/unloading operations require more time. With a growing complexity in global transport networks, managing the time factor becomes crucial for current liner service design. Shorter waiting times and delays redound in benefits to customers that save on logistics costs (Notteboom, 2006). Specifically, Wilmsmeier et al. (2006) find that port efficiency is the most determinant element of international transport costs, followed by port infrastructure, private sector participation and inter-port connectivity. Doubling port efficiency in a pair of ports involved in bilateral trade has the same impact on international transport costs as halving the distance between them. All these factors have driven liners to control a number of terminal facilities all over the world. Within the structural evolution in ports, many shipping lines have established their own terminal operating branch. To illustrate, the A.P. Møller–Mærsk group operates approximately 50 container terminals around the world. This certainly introduces an element of strategy in such vertical integration arrangements. In particular, a key decision for carriers is whether to manage a dedicated terminal and keep it exclusive or whether to have a dedicated terminal accessible to all users (thus keeping it non-exclusive). Indeed, most global carriers run their own terminals; others are shifting to common-user (non-exclusive) terminals, as done by Mærsk creation of APM Terminals and Japanese Yusin Kaisha.

The liner shipping market is characterized by a number of recent features. The most relevant are: First, it is a relatively concentrated oligopolistic market since 80% of vessel capacity is held by the top 20 carriers. Second, the trend toward consolidation in the industry, via mergers and cooperation agreements, accelerated in the past few years. Since the 1990s, carriers have been pooling vessels on main commercial routes and profiting from scope and network economies prompted by the formation of strategic alliances. Third, shipping companies now establish forms of vertical integration to get a tighter grip on logistics chains, in particular, as a means of gaining control over port capacity. Recently, Notteboom (2007) and two OECD works by Frémont (2009) and Van de Voorde and Vanelslander (2009) underline the significance of market power and of integration in the understanding of the maritime sector. The emergence of dedicated container terminals over the last years may be due to the increasing gap between the objectives of ports and those of shipping lines. Haralambides et al. (2002) provided a detailed discussion and analysis of the costs and benefits of dedicated terminals. Among the benefits, they note that dedicated terminals offer carriers greater flexibility, reliability, short turnaround times, and enhanced efficiency in the management of global supply chains. Among the costs, the presence of diseconomies of scale in ports is quoted. These are related with availability of cargo-handling equipment. The utilization of larger vessels shifts up the ship–time curve; hence average costs are minimized at a lower level of port production. Kaselimi et al. (2011) further mention that the benefits that ocean carriers may exploit when operating a fully dedicated terminal include the delivery of value added, the provision of a “one-stop-shop” service to customers, and increased profitability. Fourth, in the strong competition environment that characterizes the industry, product differentiation (through a wider range of services offered) has a strong influence on performance (Panayides, 2003).

Regarding maritime transport there are some recent papers devoted to analyze how dedicated terminals can affect the different actors of the port industry. Reynaerts (2010) empirically studies the merger between two terminal operators using a Bertrand competition model to assess its impact on profits and social welfare. Van Reeven (2010) uses a horizontal product differentiation model in which two ports compete for cargo trans-shipments. The model shows that the landlord port governance scheme without intra-port competition is a Nash equilibrium yielding the highest profits for the port industry, and the highest prices for its customers. Finally, the paper by Kaselimi et al. (2011) merits to be cited. These authors analyze a model of competition between non-dedicated terminals using a typical Hotelling specification. The impacts on the industry when one of the terminals moves towards a fully dedicated operator are evaluated. It is shown that non-dedicated terminals can result in price and profits increases. However users of these terminals clearly lose. Our paper differs from and complements the analysis by Kaselimi et al. (2011), because once a shipping line adds a new terminal, it might find it profitable to offer the terminal services to rival shipping lines.

The issues related to vertical integration and exclusivity have been widely discussed in the industrial organization literature. A question much analyzed in the field has been the foreclosure theory. The idea is that an incumbent firm might profitably exclude rivals by using exclusivity clauses. In a recent paper, Spector (2011) examines the circumstances for socially inefficient exclusion and offers an excellent discussion of earlier related literature. Also related and recent contributions have studied the competitive effects of vertical mergers: the cost efficiency of suppliers and the potential provision of specialized inputs affect the pricing behavior of downstream firms and the incentives to integrate (see e.g. Chen, 2001; Choi and Yi, 2000). In contrast with these papers, the initial situation has one input supplier whose access cannot be denied, the open terminal. The new liner terminal creates an additional input thus making the existing terminal less of an essential input; this opens the possibility for shipping lines to offer differentiated services and indeed become multiproduct firms, where demand

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2 Midoro et al. (2005) surveyed the recent history of liner shipping and talk about one evolution (growth in vessel size and in ports) and three revolutions (containerization, intermodal ship–rail transport, and transhipment). The current wave of integration and globalization of the terminal business and liners is to be put in the transhipment revolution.

3 There are pure TOCs and also other forms of partnerships between shipping lines and stevedores (such as joint ventures, contracts, and the creation of partially owned subsidiaries). See Soppé et al. (2009) for a recent review on reasons leading to the integration of vertical activities in the maritime industry. Zhang et al. (2007) provide an analysis of intermodal integration in transport chains in the airline industry.
interrelations become important. The structure of our model, though simpler than that in the aforementioned literature, sits well with the organization and performance of the maritime sector and is a contribution in the context of tapered integration (whereby a given input is bought from an affiliated supplier and from an independent one).

This paper develops an oligopoly model with vertical relations that accounts for some of the aforementioned characteristics of the maritime freight industry. The firms downstream are the shipping lines that offer differentiated freight services and operate through the upstream open port facilities. Then one of the companies invests in a private terminal. This integration of services means it can secure its port operations, save on costs and better schedule its ships. Such substantial investment can be justified by a high volume of traffic with the objective of providing better service quality. That is to say, customers will be willing to pay higher fares for that traffic through the new liner terminal, mainly because of faster transit time. The terminal is in principle a dedicated terminal of exclusive use and the carrier investor decides whether to continue using the open port facilities. However, and for strategic reasons, such investment can be best paid off if the terminal is hired to other liners at some price. All these competition scenarios are considered and compared. It allows us to examine the new business line adopted by major liners and to evaluate the opportunity of exclusive terminals. It is shown that the shipping line that invests in the new terminal finds it advantageous to operate its freight both through its own terminal and the open facilities. In this way it can segment the market and sort out those customers that are willing to pay more for a better service. In case the shipping line lets the rival use the private terminal in exchange for a fee, we find that the fare of the carrier investor is higher than the rival’s at the open facilities, whereas the opposite happens at the liner terminal. With these fares the carrier investor pushes some of the rival’s freight from the open to the new terminal. Our main finding is that the shipping line that builds its own terminal attains higher profits with a non-exclusive terminal than with a dedicated terminal; interestingly, the rival carrier also gets more profits under the non-exclusive regime. With the fee, the carrier investor partially internalizes the competition stemming from letting the rival offer a new product. Both shipping lines offer a wider variety of services, total freight increases and the resulting equilibrium fares exceed those under a dedicated terminal.

The paper is organized as follows. Section 2 provides some evidence on the recent trend regarding vertical integration in maritime freight. Then Section 3 presents the model and develops the various competition scenarios. The main results are presented and discussed. Section 4 concludes.

2. The involvement in terminals by shipping lines

As acknowledged in the Green Paper COM (97) 678 on seaports and maritime infrastructures in the European Union, and the Communication from the Commission to the European parliament and the Council, COM 2001/0047, the financing of ports and policies on charging their users vary from one country to another, reflecting the considerable differences in the approach taken towards their ownership and organization. In Europe we find state-owned ports, others that are run by local governments and some that are in the hands of private management. The lack of transparency of port accounts as well as the extensive application of subsidies and public aids disguise final prices. To illustrate, Spain’s Port System does not escape to this description. The port fares are regulated by the central government though companies offer discounts on final prices, which translates to significant dispersion of observed fares. The fact that ports tend to be seen as commercially oriented entities has driven the Spanish government to modify the Law on Ports. Although charges should follow average cost pricing or marginal cost pricing, there is still much to be done. Therefore, data on changes in market structures and volumes of freight can be useful indicators of the business strategies recently undertaken by global carriers.

Dedicated terminals are a widespread phenomena not only in Europe but also in Asia and North America. Drewry Shipping Consultants (2003) collected throughput figures for terminals in which carriers have a non-minority shareholding: Evergreen handled 5.7 million TEU worldwide on its terminals in 2002, COSCO 4.7 million TEU, Hanjin 4.7, APL 4.3, NYK Line 3.5 (including 1.3 million TEU at its subsidiary Ceres Terminals) OOCL 3, NOL 2.5, K-Line 2.2, MSC 2.2, Yang Ming 1.3 and Hyundai 1.1 million TEU. The strategy of holding dedicated and/or non-exclusive terminals becomes fundamental for these big players. Container shipping lines approach terminal management in a different way: they seek control over berths while other ‘pure’ terminal operating companies manage multi-user facilities. Some of these liner terminals offer stevedoring services to third carriers as well, thereby creating some hybrid form in between pure dedicated facilities and independently operated multi-user facilities (Notteboom, 2006).

Table 1 gathers information on the interests that many of such big carriers have in handling terminals in European ports. Although not a generalized observation, many ports have seen an increase in throughput following the opening of new terminals. Dedicated terminals have been granted recently to APM Terminals in Rotterdam and to MSC in Antwerp. Table 2 reports aggregate freight data for some European ports where terminals were recently created. For example, the ports of Zeebrugge and Le Havre have seen a notable increase since 2005 and 2006, after the opening of CMA-CGM and MSC terminals, respectively.4

Let us elaborate on a couple of specific cases to better frame the issues at stake. The objective of the big TOC’s has been to service any shipping line that approaches them, regardless of the carrier group or alliance they belong to. It is in this manner that, as just mentioned, they manage multi-user facilities. It is only recently that some TOC’s have allied with shipping lines

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4 The theoretical model precisely incorporates this fact; the new terminal creates demand for new and improved services. A robustness analysis regarding this point is given at the end.
with the purpose of ensuring preferential treatment for their cargo. Hutchison Port Holdings (HPH), a subsidiary of the international conglomerate Hutchison Whampoa Limited (HWL), lends a representative example of such strategy. HPH is one of the largest investors and terminal operators managing 52 ports in 26 countries, and handling 75 million TEU’s in 2011. HPH has based its international development of container terminals on various collaboration schemes, yet with particular emphasis on alliance agreements with local operators. This is the recent experience with the port of Barcelona, where a new semi-automated terminal has just been launched. Barcelona Europe South Terminal (BEST), operated by TERCAT, affiliated to HPH, has been appointed among the most efficient European terminals and become the most technologically advanced terminal in the Mediterranean.

On the other hand, also over the last years, we have witnessed a change in the strategies followed by some carriers which, in view of a promising line of business, have established their own container terminal companies. These terminals are run on an exclusivity basis; yet, in some cases, rival liners have been allowed their use, and all that rendering it compatible with using other terminals at the same port. Let us mention the examples of Mediterranean Shipping Company (MSC) and China Ocean Shipping Company (COSCO), major carriers that have been very active in the terminal business either via agreements with local operators, or via alliances, or via its own operated companies. Thus COSCO was present in 30 container terminals back in 2007, associated either with TOC’s or other carriers, such as MSC, handling 41 million TEU’s that year. MSC, the world second carri er per traffic volume, also takes part in the terminal business, both in exclusive terminals and multi-user terminals. Focusing on MSC’s activity at some ports we can see that the management of its partner terminals and the traffic volumes is varied:

- Port of Long Beach (USA): MSC is not using a unique strategy. Of the four existing container terminals, it operates three of them as follows:
  - Total Terminal International, LLC (TTI): owned by Stevedoring Services of America Marine (SSA) and Hanjin Shipping (Hanjin). The latter keeps an exclusive quay, while the remaining quays are indistinctly used by COSCO, PIL (Pacific International Lines), among others, and MSC.
  - Pacific Container Terminal (PPL): participated by MSC since 2001. Apart from MSC, the terminal is used by COSCO, Hanjin and PIL.

### Table 1


<table>
<thead>
<tr>
<th>Shipping line or related company</th>
<th>Terminals</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>APM terminals</td>
<td>APM Terminals Rotterdam (100%)</td>
<td>In operation since 2000</td>
</tr>
<tr>
<td></td>
<td>North Sea Terminal Bremerhaven (50%)</td>
<td>In operation</td>
</tr>
<tr>
<td></td>
<td>Medcenter–Gioia Tauro (33.3%)</td>
<td>In operation</td>
</tr>
<tr>
<td></td>
<td>Algeciras (100%)</td>
<td>In operation</td>
</tr>
<tr>
<td></td>
<td>Aarhus (100%)</td>
<td>In operation</td>
</tr>
<tr>
<td></td>
<td>APM Constanza Terminal (100%)</td>
<td>In operation</td>
</tr>
<tr>
<td></td>
<td>Genoa (100%)</td>
<td>In operation</td>
</tr>
<tr>
<td>MSC</td>
<td>MSC Home Terminal–Antwerp (joint venture with PSA)</td>
<td>In operation since 2003</td>
</tr>
<tr>
<td></td>
<td>Le Havre (joint-venture with Terminaux de Normandie)</td>
<td>In operation since 2007</td>
</tr>
<tr>
<td></td>
<td>Valencia</td>
<td>In operation since 2007</td>
</tr>
<tr>
<td></td>
<td>Las Palmas</td>
<td>In operation since 2007</td>
</tr>
<tr>
<td></td>
<td>Naples</td>
<td>In operation since 2002</td>
</tr>
<tr>
<td>Hapag-Lloyd</td>
<td>Altenwerder Terminal–Hamburg (minority stake of 25.1%)</td>
<td>In operation since 2002</td>
</tr>
<tr>
<td>CMA-CGM</td>
<td>Port Synergy (joint venture with P&amp;O Ports) with terminals in Le Havre, Marseille and Marsaxlokk</td>
<td>In operation since 2006</td>
</tr>
<tr>
<td>CMA-CGM Cosco Pacific P&amp;O</td>
<td>35% shareholding in Container Handling Zeebrugge (OHZ)</td>
<td>Since July 2005</td>
</tr>
<tr>
<td>Nedlloyd</td>
<td>Minority shareholdings in Antwerp Gateway (other shareholders: P&amp;O Ports and Duiisport)</td>
<td>In operation since September 2005</td>
</tr>
<tr>
<td>P&amp;O Nedlloyd</td>
<td>Euromax Terminal Rotterdam (joint-venture with ECT)</td>
<td>To be seen given takeover by Maersk Sealand</td>
</tr>
</tbody>
</table>

### Table 2

Number of TEUs (in thousands) moved in different European ports. Source: own elaboration.

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeciras</td>
<td>2234</td>
<td>2516</td>
<td>2937</td>
<td>3179</td>
<td>3257</td>
<td>3421</td>
<td>3328</td>
</tr>
<tr>
<td>Antwerp</td>
<td>4777</td>
<td>5445</td>
<td>6064</td>
<td>6482</td>
<td>7019</td>
<td>8176</td>
<td>8663</td>
</tr>
<tr>
<td>Le Havre</td>
<td>1720</td>
<td>1977</td>
<td>2145</td>
<td>2118</td>
<td>2138</td>
<td>2656</td>
<td>2500</td>
</tr>
<tr>
<td>Malta</td>
<td>1460</td>
<td>1321</td>
<td>1455</td>
<td>1458</td>
<td>1887</td>
<td>2260</td>
<td></td>
</tr>
<tr>
<td>Rotterdam</td>
<td>6515</td>
<td>7107</td>
<td>8281</td>
<td>9287</td>
<td>9655</td>
<td>10,791</td>
<td>10,784</td>
</tr>
<tr>
<td>Zeebrugge</td>
<td>958</td>
<td>1012</td>
<td>1196</td>
<td>1407</td>
<td>1653</td>
<td>2020</td>
<td>2209</td>
</tr>
</tbody>
</table>

With the purpose of ensuring preferential treatment for their cargo, Hutchison Port Holdings (HPH), a subsidiary of the international conglomerate Hutchison Whampoa Limited (HWL), lends a representative example of such strategy. HPH is one of the largest investors and terminal operators managing 52 ports in 26 countries, and handling 75 million TEU’s in 2011. HPH has based its international development of container terminals on various collaboration schemes, yet with particular emphasis on alliance agreements with local operators. This is the recent experience with the port of Barcelona, where a new semi-automated terminal has just been launched. Barcelona Europe South Terminal (BEST), operated by TERCAT, affiliated to HPH, has been appointed among the most efficient European terminals and become the most technologically advanced terminal in the Mediterranean.

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  - Pacific Container Terminal (PPL): participated by MSC since 2001. Apart from MSC, the terminal is used by COSCO, Hanjin and PIL.
transport, which follows from a standard quadratic utility function à la Dixit (1979), is linear in the following form:

\[ x = \beta_0 + \beta_1 y_1 + \beta_2 y_2, \]

the services offered (parameter \( a \)) and differentiation (parameter \( d \)) ranges from 0 to 1, and services are less differentiated as \( a \) approaches 1.

With the above information we learnt that dominant shipping lines are particularly involved in the use of dedicated terminals. Also that it is not unusual that those terminals be simultaneously used by rival liners thus providing anecdotal evidence to the main point raised in this paper: there is an economic rationale for letting competitors use dedicated terminals. Whether this will be the case in each particular port depends on multiple factors, which are explored next.

3. The model and results

We are interested in establishing whether a vertically integrated company prefers to keep a dedicated terminal (and continue employing the open facilities) or to let it to a rival liner. To this end we will compare prices, demand and profits under several scenarios.

3.1. Benchmark scenario

Consider one (sea) port in which two shipping lines, \( A \) and \( B \), offer differentiated freight services. The demand system for transport, which follows from a standard quadratic utility function à la Dixit (1979), is linear in the following form:

\[ Q_{AO} = a - f_{AO} + df_{BO}, \]
\[ Q_{BO} = a - f_{BO} + df_{AO}, \]

where \( Q \) represents the demand (expressed in TEU) and \( f_i \) is the fare of shipping line \( i (i = AO, BO) \) and is charged for the services of transporting a TEU between two points. This demand system has the property that lower fares are boosting transport services as the cost of the shipped product in the destination markets is lower. This effect is bounded by \( a \). Thus, parameter \( a \) corresponds with the maximum level of transport demand for either shipping line in the departing situation. If we invert the above linear demand system the actual intercept is interpreted as the maximum willingness to pay for that good. Note that a higher \( a \) implies a higher willingness to pay. All of the freight is operated through the open terminal (subscripted by \( O \)). See Fig. 1. Parameter \( d \) is related with the degree of product differentiation between the services supplied by shipping lines. It ranges from 0 to 1, and services are less differentiated as \( d \) approaches 1. This demand schedule captures horizontal product differentiation (parameter \( d \)) between the freight services, as well as vertical product differentiation regarding the quality of the services offered (parameter \( q \)). Shipping lines incur constant marginal costs of production \( c \). In addition, they are charged \( cu \) per TEU for terminal port use. We can therefore state the profit maximization problem for the shipping lines as follows:

\[ \max_{f_{AO}, f_{BO}} (\pi_{AO} + \pi_{BO}) \]
\[ \text{subject to} \]
\[ f_{AO} + f_{BO} \leq C \]
\[ f_{AO} \geq 0, f_{BO} \geq 0 \]

where \( \pi \) represents the profit for shipping line \( i (i = AO, BO) \), \( C \) is the total capacity of the terminal, and \( f_i \) is the fare of shipping line \( i (i = AO, BO) \).

\[ \pi_i = (TU_i - c_i)Q_i \]

where \( TU_i \) represents the total utility derived from shipping line \( i (i = AO, BO) \) and \( c_i \) is the constant marginal cost of production.

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where \( TU_i \) represents the total utility derived from shipping line \( i (i = AO, BO) \) and \( c_i \) is the constant marginal cost of production.

5. Competition on routes is a major determinant of transport costs, and is closely related to the total trade volume. In 2006, one in six importer/exporter pairs was served by a single liner service, and over half were served by three or fewer (Hummels et al., 2009).

6. At the aggregate level Korinek and Sourding (2009) show that a doubling in bilateral maritime transport costs (expressed in $/tonne of goods shipped) is associated with between 66% and 80% decline in the value of imports between two given countries, holding constant the effects of GDP, distance and all other determinants of imports.

7. Managerial strategies aimed at increasing differentiation from competitors, a lower \( d \), are for instance those related with travel time, reliability, meeting customers’ needs or any other aspect of the transport service.

8. That is, when both products are sold at the same price the high quality one has higher demand than the other.

Table 3

<table>
<thead>
<tr>
<th>Year</th>
<th>Open terminal</th>
<th>Terminal MSC</th>
<th>MSC through open</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>1,510,431</td>
<td>515,784</td>
<td>1,571,957</td>
<td>2,779,666</td>
</tr>
<tr>
<td>2005</td>
<td>1,674,955</td>
<td>875,946</td>
<td>2,259,669</td>
<td>5,175,839</td>
</tr>
<tr>
<td>2006</td>
<td>1,851,740</td>
<td>323,980</td>
<td>2,579,740</td>
<td>5,965,610</td>
</tr>
<tr>
<td>2007</td>
<td>1,571,957</td>
<td>875,946</td>
<td>2,259,669</td>
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<td>5,965,610</td>
</tr>
</tbody>
</table>

Source: own elaboration.
This is a standard differentiated duopoly with a symmetric equilibrium characterized by:

$$f_{AO} = (f_{AO} - c - cu)Q_{AO},$$

$$f_{BO} = (f_{BO} - c - cu)Q_{BO}.$$  \(\text{(2)}\)

This is a standard differentiated duopoly with a symmetric equilibrium characterized by:

$$f_{AO} = f_{BO} = \frac{a + c + cu}{2 - d},$$  \(\text{(3)}\)

that leads to equilibrium demands and profits given by:

$$Q_{AO} = Q_{BO} = \frac{a - (1 - d)(c + cu)}{2 - d}; \quad \pi_A = \pi_B = \left(\frac{a - (1 - d)(c + cu)}{2 - d}\right)^2.$$  \(\text{(4)}\)

Note that we need to assume that $a > (1 - d)(c + cu)$ in order to get positive equilibrium demands. However, this is a consistency assumption as it simply implies that the maximum willingness to pay for the transport service must be greater than the marginal costs of providing the service. One of the shipping lines, say $A$, sets up its own terminal at the port, which entails some fixed cost $F$. This decision will allow the shipping line to supply a better service quality. This is modeled as a change in the maximum demand parameter. Besides, the shipping line can still make use of the open port services or not. We further assume that there is no congestion at the port. These situations are analyzed next.

### 3.2. Dedicated use of the liner port terminal

#### 3.2.1. Pure use

In the case of a purely exclusive terminal, we assume that shipping line $A$ operates all its freight through its terminal, whereas shipping line $B$ only operates through the open terminal. See Fig. 2. The (asymmetric) demand system is now given by:

---

9 By inverting the linear demand system we obtain the maximum willingness to pay, which reads $\frac{a}{d}$ and it must be greater than $c + cu$.

10 De Borger et al. (2008) study the relevance of congestion when ports, which serve a hinterland, compete for traffic. Their analysis highlights that, under some circumstances, investments in port capacity can be welfare detrimental.
where $Q_{AT}$ denotes freight services of shipping line $A$ through the private terminal (subscripted by $T$); and $Q_{BO}$ (as above) corresponds to freight services of shipping line $B$ through the open terminal. As noted above, the improvement in service provided translates to the demand parameter $a$, with $\tilde{a} > a$. This presentation is flexible enough to account for any features related with reliability, securing port operations, better schedule of departures, priority, problems with cargo handling, congestion and so on. Having different advantages and disadvantages through the dedicated terminal suffices to justify different demand intercepts. Shipping line $A$ now saves on unit costs $cu$ since its freight transport is operated via its own terminal.\(^{11}\)

Therefore, the profit maximization problem faced by the shipping lines is stated as follows:

\[
\begin{align*}
\max_{f_{AT}} & \quad (f_{AT} - c)Q_{AT} - F, \\
\max_{f_{BO}} & \quad (f_{BO} - c - cu)Q_{BO}.
\end{align*}
\]  

(6)

Solving the system formed by $\partial \pi_A / \partial f_{AT} = 0$, and $\partial \pi_B / \partial f_{BO} = 0$ leads to equilibrium fares:

\[
\begin{align*}
f_{pe}^{AT} &= \frac{2(a + c) + (a + c + cu)d}{4 - d^2}, \\
f_{pe}^{BO} &= \frac{d(a + c) + 2(a + c + cu)}{4 - d^2},
\end{align*}
\]  

(7)

where superscript $pe$ stands for purely exclusive. Let $Q_{AT}^{pe}$, $Q_{BO}^{pe}$, $\pi_A^{pe}$ and $\pi_B^{pe}$ denote the equilibrium outputs and profits. It follows that, as long as $a > a + cu$, $f_{AT}^{pe} > f_{BO}^{pe}$, $Q_{AT}^{pe} > Q_{BO}^{pe}$, and $\pi_A^{pe} > \pi_B^{pe}$ (abstracting from the fixed cost $F$). The condition on $a$ is just meshing the two opposite effects on the shipping line $A$’s fares derived from the new terminal use. There is an increase in the service quality that entails an equilibrium fare rise, but also a decrease in marginal cost, since $cu$ is saved, that implies a decrease in the fare.\(^{12}\) The condition informs that only when $a$ is high enough will the final effect be an increase in fares. Interestingly, it also implies that equilibrium fares are higher than in the benchmark scenario.

3.2.2. Mixed use

In this case, both shipping lines employ the open facility whereas shipping line $A$ employs the private port terminal on an exclusivity basis. See Fig. 3. Thus, three different freight services are available depending on the shipping line and the type of terminal used. The (asymmetric) demand system is now given by:

\[
\begin{align*}
Q_{AT} &= \tilde{a} - f_{AT} + d(f_{AO} + f_{BO}), \\
Q_{AO} &= a - f_{AO} + d(f_{AT} + f_{BO}), \\
Q_{BO} &= a - f_{BO} + d(f_{AT} + f_{AO}),
\end{align*}
\]  

(8)

where $Q_{AO}$ denotes freight services of shipping line $A$ through the open terminal. Parameter $d$ now ranges from 0 to 0.5, to have that an equal decrease in all the fares implies an increase in demand. Now the profit maximization problem faced by the shipping lines is stated as follows\(^{13}\):

\(^{11}\) We normalize the liner terminal’s marginal operating cost to zero for the sake of exposition. We are just assuming that there is a cost advantage in the new terminal. Therefore, $cu$ is interpreted as the differential in operating costs once that of the new terminal is assumed to be zero.

\(^{12}\) Regarding shipping line $B$’s fare, the increase is due to strategic complementarity since $B$’s marginal profits are increasing with its rival’s fare.

\(^{13}\) We are not considering economies of scope in order to keep the model as simple as possible. Economies of scope would imply higher shipping line $A$’s profitability. Thus by assuming them away we are underestimating the positive effect of a new service in the market.
The shipping line A that builds the terminal is better off if it operates its freight through both terminals, i.e. Result 1.

\[ \max_{f_{AT}, f_{AO}} \pi_A = (f_{AT} - c)Q_{AT} + (f_{AO} - c - cu)Q_{AO} - F, \]
\[ \max_{f_{AO}} \pi_B = (f_{BO} - c - cu)Q_{BO}. \]

Solving the system formed by \( \partial \pi_A / \partial f_{AT} = 0 \), \( \partial \pi_A / \partial f_{AO} = 0 \) and \( \partial \pi_B / \partial f_{BO} = 0 \) leads to equilibrium fares\(^{14}\):

\[
\begin{align*}
  f_{AT}^* &= \frac{(a + c)(4 - d^2) + 3(a + c + cu)d(2 + d) - d(4c(1 + d) + cu(4 - d^2))}{4(2 - (3 + d)d^2)}, \\
  f_{AO}^* &= \frac{(a + c + cu)(4 + d(2 + d)) + (a + c)d(4 + d) - d(4c(1 + d) + cu(4 + d)d)}{4(2 - (3 + d)d^2)}, \\
  f_{BO}^* &= \frac{(2 - d)(a + c + cu) + d(a + c) - d^2(2c + cu)}{2(2 - d)(2 + d)},
\end{align*}
\]

where superscript \( e \) stands for exclusivity. It can also be checked that the fares are increasing with \( a \) and \( \bar{a} \), and also with \( c \) and \( cu \) as long as \( d \in (0, 0.5) \).

Given these equilibrium fares, the equilibrium demands and profits can be obtained. Let \( Q_{AT}^*, Q_{AO}^*, Q_{BO}^* \), \( \pi_A^* \) and \( \pi_B^* \) denote these expressions. It happens that \( f_{AT}^* > f_{BO}^* \) and \( Q_{AT}^* > Q_{BO}^* \) if and only if \( \bar{a} > a + cu(1 + d) \), and the same condition is sufficient for \( f_{AO}^* > f_{BO}^* \) and \( Q_{AO}^* > Q_{BO}^* \). In fact it is easily proven that \( f_{BO}^* \) grows with respect to the fare in the benchmark situation; the same happens for quantities. This is explained by the fact that more variety in services is attracting demand to the market in such a way that there is always demand for the new services.\(^{15}\)

The comparison of the pure and the mixed scenarios yields the next result:\(^{16}\):

**Result 1.** The shipping line A that builds the terminal is better off if it operates its freight through both terminals, i.e. \( \pi_A^* > \pi_B^* \).

Therefore, the owner of a new terminal will not exit the open terminal. In doing so, it can establish a sort of market segmentation device as one of its services is aimed at those customers that are willing to pay more for better service quality, while by offering the other service via the open terminal it is fighting for customers that would otherwise be patronized by shipping line B.

### 3.3. Non-exclusive use of the liner port terminal

Both shipping lines employ both the public and the new facility (see Fig. 4), which means that there are four differentiated products as gathered by the (asymmetric) demand system:

\[
\begin{align*}
  Q_{AT} &= a - f_{AT} + d(f_{AO} + f_{BT} + f_{BO}), \\
  Q_{AO} &= a - f_{AO} + d(f_{AT} + f_{BT} + f_{BO}), \\
  Q_{BT} &= a - f_{BT} + d(f_{AT} + f_{AO} + f_{BO}), \\
  Q_{BO} &= a - f_{BO} + d(f_{AT} + f_{AO} + f_{BT}).
\end{align*}
\]

\(^{14}\) The fulfilment of the second order conditions for a maximum require that \( 4(-2 + (3 + d)d^2) < 0 \), which holds for values of \( d \in (0, 0.732) \).

\(^{15}\) This is a feature clearly embedded in the representative consumer approach to product differentiation that we are considering. The introduction of a new product has always a market expansion effect than outweighs the effect of more products in the market. The convenience of this approach rather than any other is an empirical issue. That is, whether the market considered has a high potential growth or is a mature and stabilized market. We are focusing on the former situation.

\(^{16}\) The proof proceeds as follows. We first prove that \( \delta^p_{AT} (a, a, cu, c) = \pi_A^p - \pi_B^p \) is increasing in \( \bar{a} \) at an increasing rate. Therefore, \( \delta^p_{BT} (a, a, cu, c) > \delta^p_{BT} (a = a, a, cu, c) \). We then check that indeed \( \delta^p_{AT} (a = a, a, cu, c) > 0 \) for all \( d < \frac{1}{2} \).
Note that now shipping line A extracts revenue from the rival shipping line by charging a per unit fare of $t$ on B's freight through the private terminal, $Q_{BT}$. This means that shipping line A is behaving as a service provider for shipping line B thus entering into a vertical relationship. Further note that parameter $d$ ranges from 0 to 1/3. This results in the following profit maximization problem:

\[
\begin{align*}
\max_{f_{BT}, f_{AO}} & \quad (f_{AT} - c)Q_{AT} + (f_{AO} - c - cu)Q_{AO} + tQ_{BT} - F, \\
\max_{f_{BT}, f_{BO}} & \quad (f_{BT} - c - t)Q_{BT} + (f_{BO} - c - cu)Q_{BO}.
\end{align*}
\]

(12)

Solving the system formed by $\partial \pi_A / \partial f_{AT} = 0$, $\partial \pi_A / \partial f_{AO} = 0$, $\partial \pi_B / \partial f_{BT} = 0$ and $\partial \pi_B / \partial f_{BO} = 0$ leads to equilibrium fares\(^{17}\):

\[
\begin{align*}
&f_{ne}^{AO} = \frac{(2 - d)(a + c + cu) + 3d(a + c + cu) - d(2 - d)cu - 2d(1 + d)c + 3d(1 - d^2)t}{4(1 + d)(1 - 2d)} , \\
&f_{ne}^{AO} = \frac{(2 - d)(a + c + cu) + 3d(a + c + cu) - 3d^2 cu - 2d(1 + d)c + 3d(1 - d^2)t}{4(1 + d)(1 - 2d)} , \\
&f_{ne}^{BT} = \frac{(2 - d)(a + c + cu) + 3d(a + c + cu) - d(2 - d)cu - 2d(1 + d)c + (1 + d)(2 - 4d + 3d^2)t}{4(1 + d)(1 - 2d)} , \\
&f_{ne}^{BO} = \frac{(2 - d)(a + c + cu) + 3d(a + c + cu) - 2d(1 + d)c + 3d(1 - d^2)t}{4(1 + d)(1 - 2d)} .
\end{align*}
\]

(13)

Again, it is straightforward to see that the fares are increasing with $a$ and $c$, with $c$ and $cu$ as long as $d \in (0, 1/3)$; these costs enter symmetrically in all the expressions. The unit fare $t$ affects positively and in the same magnitude the fares for shipping line A. Besides, $f_{ne}^{BT} > f_{ne}^{AO}$ and $f_{ne}^{BO} > f_{ne}^{AO}$, i.e., the fare of freight through the liner terminal is higher for shipping line B, whereas the fare of freight through the usual facilities is higher for shipping line A. It is interesting to note that those fare differences arise as long as $t > 0$. When $t$ is zero, freight services at the same terminal have the same equilibrium fares. The fares at the new terminal exceed those at the open terminal if and only if $a > a + (1 + d)cu$. Besides as services become more differentiated, i.e. lower $d$, the fare difference in the liner terminal increases, while that difference at the open terminal decreases. Regarding the pricing policy within a shipping line, it always happens that the high quality service is priced higher that the low quality one if $a$ is big enough and regardless of the per unit fare on B’s freight via the new terminal. The next result summarizes our findings:

**Result 2.**

(i) Within the private terminal we have that $f_{ne}^{BT} > f_{ne}^{AO}$ whereas within the open terminal $f_{ne}^{BO} > f_{ne}^{AO}$.

(ii) Shipping line A sets fares such that $f_{ne}^{AT} > f_{ne}^{AO}$ whereas for shipping line B, $f_{ne}^{BT} > f_{ne}^{BO}$ as long as $a > a + (1 + d)cu$.

The equilibrium fares are substituted back in the profit function $\pi_A$ to obtain the per unit fare $t$ that shipping line A charges shipping line B for the use of its terminal. Setting $\partial \pi_A / \partial t$ equal to zero and solving for $t$ yields\(^{18}\):

\[
t_{ne} = a(2 - 6d + 4d^2 + 3d^3) + ad(2 - 4d + 3d^2) - 2c(1 + d)(1 - 3d)(1 - 3d + 3d^2) + cud(11 - 6d + d^2) + \\
\]

(14)

where it is easily checked that $t_{ne} > cu$.\(^{19}\) Regarding freight services the following ranking is established $Q_{ne}^{BT} > Q_{ne}^{AO} > Q_{ne}^{BO} > Q_{ne}^{AO}$. This happens for all possible $t > 0$, where (i) $Q_{ne}^{BT} > Q_{ne}^{AO}$ since $f_{ne}^{BT} > f_{ne}^{AO}$, (ii) $Q_{ne}^{BO} > Q_{ne}^{AO}$ since $f_{ne}^{BO} > f_{ne}^{AO}$, (iii) $Q_{ne}^{BT} > Q_{ne}^{BO}$ if and only if $a > a + (1 + d)(t_{ne} - cu)$ since $t_{ne} > cu$. Finally, $Q_{ne}^{BT} > Q_{ne}^{AO} if and only if $a > a + (1 + d)(t_{ne} - cu)$ - 3d(1 + d)t_{ne}$. Besides, it can be checked that prices go up relative to the mixed use scenario, that is, $f_{ne}^{BO} > f_{ne}^{AO}$ and $f_{ne}^{BO} > f_{ne}^{BO}$.

We may now compare whether shipping line A finds it strategically advantageous to have a privately built terminal on a non-exclusive regime. The next result summarizes the main finding in our paper.\(^{20}\)

**Result 3.** Regardless of the value $a$ and for $d \in (0, 1/3)$,

(i) Shipping line A is better off with a non-exclusive terminal, i.e. $\pi_{ne}^{AT} > \pi_{ne}^{AO}$.

(ii) Shipping line B is also better off with a non-exclusive terminal, i.e. $\pi_{ne}^{BO} > \pi_{ne}^{AO}$.

(iii) The fares are higher under a non-exclusive regime, i.e. $f_{ne}^{AT} > f_{ne}^{AO}$, $f_{ne}^{AO} > f_{ne}^{BO}$ and $f_{ne}^{BO} > f_{ne}^{BO}$.

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17 The fulfillment of the second order conditions for a maximum require that $16 - 48d^2 - 32d^3 > 0$, which holds for values of $d \in (0, 0.39)$.
18 The fulfillment of the second order condition requires that $d \in (0, 0.39)$.
19 Fares rankings are obtained directly just using that $d < 1/3$ and $a > a$. In order to prove part (i) we first prove that $A_{ne}^{BT}(a, a, cu, c) = \pi_{ne}^{BT} - \pi_{ne}^{AO}$ is increasing in $a$ at an increasing rate. Therefore, $A_{ne}^{BT}(a, a, cu, c) > A_{ne}^{BT}(a, a, a, cu, c) > A_{ne}^{BT}(a, a, a, a, cu, c) > 0$ for all $d < 1/3$. Similarly for (ii), define $A_{ne}^{BO}(a, a, cu, c) = \pi_{ne}^{BO} - \pi_{ne}^{AO}$, which is also increasing in $a$ at an increasing rate, therefore $A_{ne}^{BO}(a, a, a, cu, c) > A_{ne}^{BO}(a, a, a, a, cu, c)$. We next prove that $A_{ne}^{BO}(a, a, a, cu, c) > 0$ for any $d < 1/3$.
20 Fares rankings are obtained directly just using that $d < 1/3$ and $a > a$. In order to prove part (i) we first prove that $A_{ne}^{BT}(a, a, cu, c) = \pi_{ne}^{BT} - \pi_{ne}^{AO}$ is increasing in $a$ at an increasing rate. Therefore, $A_{ne}^{BT}(a, a, cu, c) > A_{ne}^{BT}(a, a, a, cu, c) > A_{ne}^{BT}(a, a, a, a, cu, c) > 0$ for all $d < 1/3$. Similarly for (ii), define $A_{ne}^{BO}(a, a, cu, c) = \pi_{ne}^{BO} - \pi_{ne}^{AO}$, which is also increasing in $a$ at an increasing rate, therefore $A_{ne}^{BO}(a, a, a, cu, c) > A_{ne}^{BO}(a, a, a, a, cu, c)$. We next prove that $A_{ne}^{BO}(a, a, a, cu, c) > 0$ for any $d < 1/3$.
The intuition of the result is as follows. As previously explained, more variety in the market implies higher demand: the increase in port facilities makes this spot attractive for customers. This is beneficial for both shipping lines. Thus, shipping line B is better off since it now is providing two differentiated services. For shipping line A the reason is different; by letting the rival use the new terminal, shipping line A is better off since it is getting a share of the profits coming from the new product. In fact, shipping line A has the upper hand in the market since by choosing the rate, which is a marginal cost for shipping liner B, is able to partially internalize the competition it suffers from the new product. This not only produces a change in the carriers pricing incentive but also distorts the rival’s incentive in choosing which terminals to operate with. To close the argument, and since equilibrium fares are increasing in t, a higher t helps sustain higher prices in the market which raises the profitability of shipping line A’s products as well as B’s.21

Regarding the potential for entry deterrence by shipping line A’s new terminal, it must be noted that the mere existence of an open port facility makes “complete” deterrence impossible. That is to say, the default option to use the existing terminal is available despite shipping line B being deprived of using the new terminal and then deterred from offering a better service quality. Although this is possible the model predicts that it is not profitable for shipping line A. Let us finish with a word about welfare implications. A series of numerical examples, leaving the parameter related to the degree of horizontal product differentiation open, reveals the following ranking in social welfare $SW^{PE} > SW^w > SW^{NE} > SW^o$. The same pattern is obtained regarding industry profits and user surplus.

We wish to note that the assumption of linear demands is not fundamental to the conclusions. A general demand system satisfying a set of regularity conditions would lead to qualitatively similar results. These conditions are that the demand for a particular freight service be decreasing with own price (own effects are negative), and increasing with other prices since services are substitutes (cross effects are positive). Furthermore, an equal variation of all prices must result in a demand reduction (own effects dominate cross effects). Finally, standard conditions about stability of equilibria (diagonal dominance), strategic complementarity and that first-order effects dominate second-order effects (so that the objective functions are smooth enough) guarantee that comparative statics analysis as in the linear case follows immediately and is intuitive.22

One may wonder what would happen were there a differential treatment in the dedicated terminal between own ships and those of the competitor. This contingency could be easily encompassed in the model presented by assuming a lower increase in the intercept of service demand $Q_{BT}$. Asymmetries of this kind do not change the price orderings across and within the organizational structures studied.23 Another simplifying assumption in the analysis has been the passive role played by the port operator managing the open terminal.24 However, this is the actual situation in a large number of public ports where those fees, $cu$, are regulated. We have solved numerically the model considering an extreme reaction from the port authority which consists of matching the operating costs of the dedicated terminal, i.e., $cu = 0$, to find that the non-exclusive use of the dedicated terminal is the option chosen by shipping line A.

In order to further check the robustness of our main result, consider an alternative specification of the utility function (see Shubik and Levitan, 1980) with the property that more variety does not necessarily imply greater aggregate demand. Shipping lines will prefer the non-exclusive use of the terminal provided there is a minimum increase in the quality of service associated to the use of the new terminal.25

We have therefore provided a neat result that may explain the strategy of holding non-exclusive terminals. It is nevertheless true, as noted above, that some carriers opt for investing in terminals that are exclusively used by the owner carriers. This may happen for strategic reasons when the increase in service quality is small coupled with strong freight differentiation, had we assumed the aforementioned demand system à la Shubik–Levitan. Alternatively, when the provision of service is costly and is chosen by the terminal operator, competition in both price and non-price variables can also provide an incentive to exclusivity (see Moner-Colonques, 2006). Finally, the consideration of capacity constraints in port terminals would offer another explanation to the existence of dedicated terminals (Kaselimi et al., 2011). One way or another, the management of port terminals, whether dedicated or not, is actually determined by a number of factors such as hinterland services, port characteristics and the nature of port competition, as well as by the particular regulatory framework in a country or region. Dedicated terminals might deliver some benefits which would not otherwise be attained; yet they might create entry barriers thus limiting competition between shipping lines.

21 Note that increasing returns to scale would make the modeling much more difficult without adding too much to the analysis. Suppose, for instance, that the cost function of shipping lines is $C_i = C_0 - \frac{Q_i^2}{2}$ which incorporates scale economies for $i > 0$. This function would imply greater equilibrium outputs in the benchmark case. In the absence of scale economies, the model predicts an increase in traffic volumes in the non-exclusive use of the new terminal. Therefore, the presence of scale economies of scale will reinforce this effect making the move to that scenario even more profitable.

22 The analysis on this point is available upon request.

23 Computations are available on request.

24 Defilippi and Flor (2008) study the role of a regulatory framework on access and pricing for port infrastructures; they examine the effects on facilitating further private investment in developing countries.

25 The utility function considered is: $U(q_1, q_2, \ldots, q_n) = \sum a_i q_i - \frac{\gamma}{2} \sum q_i^2 + \frac{\beta}{2} \sum q_i^2 + y$, where $y$ is an outside option, $q_i$ is the quantity of the ith product, $a_i$ is the maximum willingness to pay for product $i$, $n$ is the number of products in the industry and $\gamma \in [0, \infty)$ is the degree of substitutability between the $n$ products. Focusing on the case where the maximum willingness to pay for products $Q_{BT}$ and $Q_{BT}$ is equal to $a$, whereas those for $Q_{BT}$ and $Q_{BT}$ equal to one and zero costs, the non-exclusive terminal is chosen for all $a > \sqrt{2}$. Details are available from the authors upon request.
4. Conclusions

Top shipping lines have aimed at reducing their production costs, diversifying their investments and achieving paths of vertical integration along the transportation chain (Panayides and Cullinane, 2002). This paper has considered a private investment in a container terminal to examine (i) whether it is strategically profitable for a shipping line to integrate services in the logistic chain while still routing cargo through the open port facilities, and (ii) whether to keep a dedicated or a non-exclusive terminal. Although the results cannot be generalized to the whole population of ports and container terminals, the moral of our model is simple, if firms are not limited either by capacity constraints or by managerial abilities, they will employ non-exclusivity as a way to capture more market share and gain some control over the rivals.

An important concern for policy-makers and researchers in the maritime industry has to do with identifying factors explaining differences in shipping rates (see Korinek and Sourding, 2009). What our analysis highlights is that factors, such as market structure, port services and infrastructures can be useful in better understanding the existing differences among shipping costs across ports. By comparing several competition regimes, we have shown that, firstly, a shipping line with a dedicated terminal will be interested in deviating part of its traffic through the open terminal. Secondly, it will also find it profitable to supply its terminal services to other shipping lines. In this case, more differentiated products are offered, and production will be maximal in the non-exclusivity case. In terms of policy implications this is an interesting result because the non-exclusive use of the liner terminal enhances social welfare - liners’ profits are higher and so is total freight. Strategically, the liner that invests in a new terminal, optimally chooses fares in such a way that part of the rival’s traffic is diverted from the open terminal: a higher share of better freight service is provided, total freight increases and fares are higher.

The paper can be extended in a number of directions. The sea transport chain between an origin and destination via two ports involves a land leg and a sea leg, in addition to port transit, on which we have focused. Thus it might be worth studying the convenience of integrating further activities; hinterland access conditions can be a fundamental element in the modeling of port competition (Zhang, 2008; Zhang et al., 2010). Further research should address the interaction of maritime transport with competing modes of transport to more faithfully assess the convenience of certain strategies and policies.

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