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Abstract

Regulating seaports is difficult in general, even more so for the weak regulatory institutions common in developing countries. For this reason some countries have awarded these facilities via Demsetz auctions, to the port operator that bids the lowest cargo-handling fee. A major concern with Demsetz auctions in this context, is that the winning operator may integrate with a shipper and monopolize the shipping market, by worsening the service quality for competing shippers. The standard policy recommendation against service quality discrimination is to ban the seaport from operating in the shipping market. The effectiveness of such prohibitions is suspect, however, because they can be circumvented by an (illegal) underhand agreement between the port operator and the shipper. In this paper we show that a ban on integration increases welfare if it is combined with a (sufficiently high) floor on the cargo-handling fee that operators can bid in the auction. In the absence of such a floor, however, a Demsetz auction is worse than no regulation at all of the bottleneck monopoly.

Our results apply beyond the port and shipping markets, to any essential facility that can monopolize a downstream market. The results only require that profits with underhand vertical integration agreements be less than with legal vertical integration.

Key words: auctions, ex ante vs. ex post rents, Demsetz auctions, hidden action, monopoly regulation, productive efficiency, vertical integration.

JEL classification: D44, L12, L92.

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1 Introduction

Regulating seaports is difficult in general, even more so for the weak regulatory institutions common in developing countries.[2] For this reason some countries have awarded these facilities via Demsetz auctions, to the firm that bids the lowest cargo-handling fee.[3] A major concern with Demsetz auctions in this context, is that the winning port operator may integrate with a shipper and monopolize the shipping market, by worsening the service quality for competing shippers. The standard policy recommendation against service quality discrimination is to ban the seaport from operating in the shipping market. The effectiveness of such prohibitions is suspect, however, because they can be circumvented by an (illegal) underhand agreement between the port operator and the shipper. In this paper we show that a ban on integration increases welfare if it is combined with a (sufficiently high) floor on the cargo-handling fee that operators can bid in the auction. In the absence of such a floor, however, a Demsetz auction is worse than no regulation at all of the bottleneck monopoly.

Before providing the intuition for our results, we briefly review our main assumptions. First, a port that is integrated with a shipper can lower quality for competing shippers, driving them out of business. Second, monopoly profits for a port that integrates with a shipper are lower with underhand vertical integration than with open integration. This gap can be specified in many ways. One of them notes the inability of making legally binding contracts with underhand agreements, which makes it easy to expropriate specific investments. Another, and this is the one we model explicitly, is based on heterogeneous and unobservable costs of shipping firms. In this case, expected shipping costs of the integrated monopoly are higher than those of the shipping companies that survive in a competitive environment. More important for our purposes, the difference in profits is larger when (open) vertical integration is forbidden, since a standard adverse selection model shows that in this case the seaport must pay an informational rent and must distort production in order to have the shipper reveal her costs. Third, the port facility is awarded in a competitive auction that proceeds as follows. Identical port operators bid both a cargo-handling fee and an up-front transfer to the government. Cargo-handling fees cannot be lower than the floor set by the regulator, and the operator bidding the lowest fee wins. If two or more operators tie for the lowest fee, the winner is the one among them that offered the highest up-front payment.[4]

To understand the intuition underlying our main results, we analyze next two polar cases. In the first one the regulator sets no floor in the auction. In the second one, the floor is set at the fee that allows the shipper to extract all rents from the shipping market (in what follows we refer to this fee as the *monopoly fee*).

Consider first the case with no floor. Since underhand agreements lead to rents for the port operator, competition for the franchise drives fees to zero, and rents are dissipated through the up-front payment to the government. With a zero fee (more generally with a fee below average costs), the winner makes profits

[2] See Trujillo and Nombela (2000) for a description of port operations.

[3] This is sometimes known as “competition for the field” (instead of in the field) and goes back at least to Chadwick (1859). Demsetz (1968) showed that this simultaneously achieves ex post rent extraction and second-best efficient pricing (yet see Williamson (1976, 1985) for a critique).

[4] If the draw persists, the winner is determined by lot.

only if it chooses vertical integration. The absence of a floor is relevant *ex-ante*, since it determines the market structure chosen by the winner (integration over separation), but plays no role *ex-post*, since the cargo-handling fee turns out to be a transfer within the integrated operator-shipper monopoly.

Consider next what happens with a floor equal to the monopoly fee. With this fee, the winning operator prefers a competitive shipping market, since it extracts all rents from shippers (as in the case with zero floor) while avoiding the downside of integration (cost and production inefficiencies due to asymmetric information). That is, expected profits are higher under separation. It follows that operators will bid the floor and the port will go to a bidder offering an up-front payment equal to expected rents under separation. Note that there is a threshold fee such that if the floor is set above this level, the operator prefers separation, whereas it chooses vertical integration if the floor is set any lower, in which case the fee becomes an internal transfer and its level plays no role in determining profits.

The welfare comparison of both scenarios is straightforward. In both cases the resulting market structure has the inefficiencies associated with monopoly pricing. Yet a floor equal to the monopoly fee leads to a competitive shipping market, avoiding the inefficiencies of underhand integration. The latter case is equivalent to an unregulated monopoly,[5] which explains why a Demsetz auction without a floor leads to lower welfare than an unregulated monopoly.

Next, we characterize the socially optimal floor. Due to competition, the winning fee is always equal to the floor set by the regulator, whatever its level. Recall that the threshold floor is the one where the operator is indifferent between integration and separation. The floor does have an impact on social welfare and *ex-post* profits when it lies above this threshold: a rise in the floor lowers welfare and increases *ex post* profits. When the floor is set lower, there is vertical integration, with its attendant inefficiencies, and lower social welfare. Hence the socially optimal floor is the threshold fee.

If there are vertical restrictions in place, only underhand integration is possible. Since profits are lower than under open integration, the threshold fee, and therefore the optimal floor, is lower than when integration. It follows that prohibiting (open) integration raises welfare.

The results in this paper apply far beyond seaports, to any industry where a potentially competitive segment requires the services provided by natural monopoly bottlenecks, the so-called *essential facilities*. For example, electric transmission and distribution are essential facilities for competitive power generators and suppliers; so is the last mile in telecoms for competitive internet service providers or long distance carriers; and seaports and airports for transportation companies. For expositional convenience, we talk about "seaports" when we mean essential facilities, "shipping companies" when we have in mind the downstream market and "cargo-handling fee" (or simply fee) for the marginal charge on the use of the essential facility.

Our paper is related to the literature of monopoly regulation via franchising which was pioneered by Chadwick (1859) and Demsetz (1968) (see also Stigler (1968), Posner (1972), Williamson (1976, 1985), Riordan and Sappington (1987), Spulber (1989, Chap. 9), Laffont and Tirole (1993, Chap. 7 and 8), Harstad

[5]As is well known (see Spengler (1950)), if the downstream market is competitive and in the absence of economies of scope, there are no incentives for vertical integration, since the monopoly fee for the use of the essential facility extracts all rents from the downstream market.

and Crew (1999) and Engel, Fischer and Galetovic (2001)). We contribute to this literature by studying the interaction between the Demsetz auction and the downstream *ex-post* market structure, allowing for the possibility of underhand vertical integration. We show that departing from second-best pricing and leaving *ex post* rents in the pockets of the monopolist can be welfare increasing when competition in the auction affects *ex post* market structure.[6] Moreover, *ex post* rents need not conflict with full *ex ante* rent extraction.

Our paper is also related to Vickers (1995) who studied vertical integration by a monopoly optimally regulated à la Baron and Myerson (1982) into an industry with symmetric firms under Cournot competition (see also Lee and Hamilton (1999)). We differ from Vickers in that in our model the monopoly is regulated by a Demsetz auction. Moreover, firms are asymmetric in the downstream market, which enables us to consider the selection role of competition. Finally, the downstream market is competitive but can be monopolized by lowering quality to rival firms. We thus study the effects of vertical integration on downstream market structure when quality degradation is a problem, a problem studied by Economides (1998, 1999) in the case of an unregulated monopoly that is vertically integrated with one of many downstream firms competing Cournot (see also Salop and Scheffman (1987)). Finally, note also that Laffont and Tirole (2000, Chap. 4) provide a complete analysis of regulation under the standard models of one-way access to an essential facility.

The rest of the paper proceeds as follows. In Section 2 we describe the recent seaport auctions in Chile. This case study motivates some of our assumptions and provides an application of the model. In Section 3 we show that vertical separation and asymmetric information on costs force the port to share rents. In Section 4 we study the relation between auction outcomes, downstream market structure and welfare. Section 5 discusses several extensions of the basic model. Section 6 briefly summarizes the results of the Chilean port auction. Finally, several appendices include the main proofs and formalizes extensions.

2 The Chilean seaport auctions[7]

Chile is a country isolated from its neighbors by deserts and mountain ranges. Hence the importance of sea-borne trade, which represents a large fraction of its GDP. The Chilean coastline, while long, offers few sites at which important ports can be built without incurring in large sunk investments in breakwaters. Consequently, there are only three large ports for general cargo (as opposed to bulk cargo).

Traditionally, these ports had been state owned, but in 1981, in response to the inefficiencies of state management, the government allowed private firms to unload, store and customs process cargo. Productivity improved substantially under the new regime. Nevertheless, by the mid-nineties, the main Chilean ports had become congested and the government began to look for alternatives to public funding of additional infrastructure. After consulting with experts, it concluded that further productivity improvements could be achieved only if each individual port was operated by a single firm, which would internalize the benefits of

[6] See Laffont and Tirole (2000, p. 177) for the analogous case in which downstream competitors would prefer to insist on an access price floor to avoid exclusion.

[7] See Foxley and Mardones (2000) for a description of the Chilean seaport auctions.

investing in large-scale specialized cranes, of improving the coordination of activities within each port and of investing in other activities with important externalities.[8] The expectation was that efficiency gains could at least double the capacity of the ports without any further investments in basic infrastructure.

To ensure that users benefit from productivity improvements, the government designed a competitive auction to award the ports to the firm bidding the lowest cargo handling fee. Nevertheless, regulators feared that if shipping companies won the auction, they would monopolize the port by favoring their own operations and lowering service quality for competitors. The advantages of Demsetz auctions would be lost in the process. Even though the regulator sets minimum quality standards, these are difficult to monitor and enforce under the Chilean regulatory and legal system. Thus it is unlikely that quality standards would help avoid monopolization.

This analysis led to restrictions on horizontal and vertical integration that were supposed to prevent monopolization. First, the Antitrust Commission, at the request of the government, established that no single firm could operate all three ports. Second, shipping companies could own not more than 40% of a port operators' equity.[9] In addition, the government fixed a floor for the cargo handling fee. If two or more firms bid the floor fee in the auction, the port is awarded to the firm that offered the highest lump sum payment.[10]

The main Chilean shipping and stevedore companies challenged the restrictions to vertical and horizontal integration in court. They argued that the restrictions would favor foreign operators; and, moreover, that restrictions would be ineffective or unnecessary because a vertically-separated port could easily replicate the integrated outcome by granting a monopoly to one shipping company in exchange for underhand payments. In addition, they argued that two of the main ports (Valparaíso and San Antonio) compete with each other since they are less than 60 miles away, so there was no danger from monopolization of a port. We will examine these arguments below.

3 Vertical separation and rent sharing

In this section we show that when there is asymmetric information about the costs of shipping companies, an underhand agreement forces the port to share rents with the shipping company even when there are many potential shipping companies. Thus, prohibiting vertical integration imposes a cost on the port.[11] We start by describing the basic model and then solve the port's optimization problem. In the next section we study

[8]For example, Mardones (1999, personal communication) argued that firms did not invest in their worker's human capital because they might be hired away by competitors within the port.

[9]This restrictions applied to *relevant shipping companies*, that is, those that carry more than 25% of the cargo transferred in the *region* during the previous year (regions are an administrative division of Chile). It is also worth noting that this is a prospective rule, in the sense that it must hold during the life of the franchise. See Foxley and Mardones (2000) for more details.

[10]The floor was fixed so as to cover the rental value of capital invested in the preexisting infrastructure of the port (breakwaters, esplanades, etc). The argument of the regulator was that a lower fee would have prevented the entry of new ports, since they would be unable to compete with franchised ports that need not cover returns on preexisting infrastructure.

[11]As we have mentioned, the possibility of expropriation of specific investments is an alternative way of imposing costs of an underhand agreement on the port.

the auction of the port franchise.

3.1 The model

The inverse demand for shipping and handling cargo is $p = D(q)$, with $D' < 0$, where q is the total quantity of cargo handled and p is the price paid by users to shipping companies. We assume that the price p covers all necessary arrangements with the port (see Table 1 for the notation used throughout the paper)

There is a continuum of shipping firms, each with constant average cost of transporting cargo equal to s. A fraction $\lambda \in (0,1)$ of shipping companies has a low average cost of s_ℓ per unit of cargo while the remaining shipping companies have a high average cost $s_h > s_\ell$. The port's average cost of handling a unit of cargo is constant and equal to c. Moreover, we assume that the port is able to lower quality enough to price any shipping company out of the market.

For future reference it is useful to distinguish four possible vertical structures:

Unregulated monopoly with vertical separation: The port is free to choose its fee but is not integrated into the shipping market. There is perfect competition among shipping companies and only low-cost firms survive.

Regulated monopoly with vertical separation: In this case, the port charges the fee with which it won the auction. The downstream market works as in the previous case.

Vertical integration: The port is matched at random with a shipper, thus the probability of integrating with a low-cost shipper is λ. The port gets to know the shipper's costs after starting operations and excluding other firms. The fee bid in the auction is irrelevant.

Underhand integration: The port establishes an underhand agreement with a randomly chosen shipping company and then discriminates against other shipping companies to exclude them from the market. The shipper knows its cost while the port does not and must offer a truth-revealing contract. Again, the fee bid in the auction is irrelevant.

We now study the optimal underhand contract.

3.2 Underhand agreements

Suppose that vertical integration is prohibited but the port can choose at random a shipping company, establish an underhand contract with it and degrade the quality to rivals in order to exclude them. The only observable variable that can be used in the underhand contract is the amount of cargo q that is handled through the port. Since the shipping company belongs to one of two types, the port can offer a menu of contracts

$$A_i + r_i q_i,$$

Table 1: Notation used throughout the paper

SYMBOLS

$D(q)$:	inverse demand for shipping
$q(p)$:	demand for shipping
q:	cargo handled
p:	price paid by users
c:	constant average cost of port operations
s:	shipping company's marginal cost
λ:	fraction of low-cost shipping companies
A:	fixed fee paid by shipping company with underhand agreement.
r:	per-unit fee paid by shipping company with underhand agreement.
Π:	joint port and shipping profits
$\pi(A,r)$:	port profits with underhand agreement
π^v:	port profits with volume operation
W:	welfare
w:	open cargo handling fee per unit

SUB AND SUPERSCRIPTS

*:	outcomes with an underhand agreement
ι:	outcomes with a vertically integrated monopoly
v:	volume
ℓ:	low cost
h	high cost

$i = \ell, h$ where A_i is a fixed amount and r_i is a per-unit fee.[12] The revelation principle implies that the port will maximize its rent by using a direct, incentive–compatible mechanism such that $(A_i, r_i)_{i=\ell,h}$ maximize

$$\lambda[A_\ell + (r_\ell - c)q_\ell] + (1-\lambda)[A_h + (r_h - c)q_h] \tag{1}$$

subject to

$$(p_i - s_i - r_i)q_i - A_i \geq 0, \quad i = h, l, \tag{2}$$

$$(p_\ell - s_\ell - r_\ell)q_\ell - A_\ell \geq (p_h - s_\ell - r_h)q_h - A_h, \tag{3}$$

$$(p_h - s_h - r_h)q_h - A_h \geq (p_\ell - s_h - r_\ell)q_\ell - A_\ell, \tag{4}$$

$$(p_i - s_i - r_i) + q_i D_i' = 0, \quad i = h, l, \tag{5}$$

where $D_i' \equiv D'(q_i)$. The first pair of inequalities (2) represents the two standard participation constraints. Since the agreement is illegal, there are no legally binding contracts and the port must ensure the shipping company at least zero profits regardless of the shipping company's cost.[13] The next pair of inequalities, (3) and (4), are standard incentive–compatibility constraints. The last equality (5) appears because the shipping company is free to choose a price that maximizes monopoly profits given it faces costs $s_i + r_i$.

Solving this problem leads to the following result:

Proposition 1 *Let $(A_i^*, r_i^*)_{i=\ell,h}$ be the contract that solves (1)–(5); let $(p_i^*, q_i^*)_{i=\ell,h}$ be the corresponding quantities and prices chosen by the shipping company and $\Pi(q_i^*)$ the combined profits. Moreover, let $(A_i^\iota, r_i^\iota)_{i=\ell,h}$ be the contract that the port would impose if it knew the shipping company's costs, $(p_i^\iota, q_i^\iota)_{i=\ell,h}$ the corresponding prices and quantities and $\Pi(q_i^\iota)$ the corresponding combined profits. Then*

(a) $r_\ell^* = c = r_\ell^\iota$ and $r_h^* = c + \frac{\lambda}{1-\lambda}(s_h - s_\ell) > c = r_h^\iota$;

(b) $p_\ell^* = p_\ell^\iota$ and $p_h^* > p_h^\iota$;

(c) $A_\ell^* < \Pi(q_\ell^*) = \Pi(q_\ell^\iota) = A_\ell^\iota$ and $A_h^* + (r_h^* - c)q_h^* = \Pi(q_h^*) < \Pi(q_h^\iota) = A_h^\iota$.

Proof: See Appendix A. ∎

Note that the full-information contract $(A_i^\iota, r_i^\iota)_{i=\ell,h}$ replicates the outcome of a vertically integrated port. Hence, Proposition 1 shows that the restriction on vertical integration reduces port profits for two reasons. First, the port sets a per-unit charge of $r_h^* > c$, which distorts (optimally) the decisions of the high-cost shipper. Second, the port must transfer an informational rent to the low-cost shipper. Since $s_h > s_\ell$ and

[12] Note that this assumption rules out the possibility of auctioning the underhand contract. If that could be done, a low-cost shipper would win the auction and no inefficiency would occur. We believe, however, that running an underhand auction is unlikely to be feasible when vertical integration is illegal. Moreover, under such circumstances a contract cannot be enforced. Thus, nothing would prevent the winner of such an auction of claiming higher costs ex post, if it were convenient to do so.

One could also argue that over time the port will eventually learn the cost of the shipper. We consider this possibility below.

[13] Since there is only one match in the game, in principle we have a bilateral monopoly. We will assume all the negotiating power belongs to the port (i.e., the worst case scenario for our analysis, since the loss to the port from an underhand agreement is the lowest).

$(p_h^* - s_h - r_h^*)q_h^* - A_h^* = 0$, the low-cost shipper makes a profit

$$(p_h^* - s_\ell - r_h^*)q_h^* - A_h^* = (s_h - s_\ell)q_h^* > 0$$

by claiming that its cost is high. This sets a lower bound on the rent that the low-cost shipper receives. We have that the port's expected utility under vertical separation is

$$\mathsf{E}_i\pi(A_i^*, r_i^*) = \lambda A_\ell^* + (1-\lambda)\Pi(q_h^*),$$

where $\pi(A,r)$ are the port's profits when establishing an underhand agreement which charges a fixed fee A and a per-unit fee r. These profits are lower than the profits of a vertically integrated port

$$\mathsf{E}_i\pi(A_i^\iota, r_i^\iota) = \mathsf{E}_i\Pi(q_i^\iota) = \lambda\Pi(q_\ell^\iota) + (1-\lambda)\Pi(q_h^\iota),$$

since $A_\ell^* < \Pi(q_\ell^\iota)$ as shown in Proposition 1.

For future reference it is useful to compute aggregate welfare with underhand and vertical integration. Let $\mathrm{W}(q)$ be aggregate welfare when q units of cargo are handled, then

$$\mathsf{E}_i\mathrm{W}(q_i^*) \equiv \lambda\left[\int_0^{q_\ell^\iota} D(q)\mathrm{d}q - (c+s_\ell)q_\ell^\iota\right] + (1-\lambda)\left[\int_0^{q_h^*} D(q)\mathrm{d}q - (c+s_h)q_h^*\right]$$

and

$$\mathsf{E}_i\mathrm{W}(q_i^\iota) \equiv \lambda\left[\int_0^{q_\ell^\iota} D(q)\mathrm{d}q - (c+s_\ell)q_\ell^\iota\right] + (1-\lambda)\left[\int_0^{q_h^\iota} D(q)\mathrm{d}q - (c+s_h)q_h^\iota\right].$$

Clearly $\mathsf{E}_i\mathrm{W}(q_i^*) < \mathsf{E}_i\mathrm{W}(q_i^\iota)$ since $q_h^* < q_h^\iota$. Moreover, if the cost of the shipping company is low, aggregate welfare under vertical integration equals welfare under separation.

4 Auction design

In the previous section we showed that vertical separation reduces the attractiveness of monopolizing the shipping market. In this section we study the interaction between the restrictions on vertical integration and the rules of the auction.

4.1 Timeline

The timing of the game is as follows:

1. The regulator sets a floor $\underline{w}$ for the fee per unit of cargo.

2. Each bidder $i = 1, \ldots, n$ submits a bid $(w_i, G_i) \in \mathrm{IR}_+^2$, where w is the per unit cargo handling fee and G is an up-front payment to the government.

3. If $\min_j w_j > \underline{w}$, the port is awarded to the firm bidding $\min_j w_j$.[14] If $\min_j w_j \leq \underline{w}$ the port is awarded, among the firms that bid $\underline{w}$ or less, to the one that offers the largest G_j.[15]

4. After the franchise is awarded the port chooses one of two strategies. Under the $\mathcal{U}$ (underhand) strategy, it establishes a monopolization agreement with a shipping company chosen at random. Under the $\mathcal{V}$ (volume) strategy, it operates the port so as to maximize the volume of cargo, charging $\min_j w_j$ per unit.

5. If the port decides to use the $\mathcal{U}$ strategy then:
   - The port offers the shipping company a take-it-or-leave-it underhand contract.
   - The port lowers service quality to rivals and the market is monopolized.
   - The shipping company learns its cost and the contract is implemented.

6. If the port chooses the $\mathcal{V}$ strategy, there is free competition in the shipping market.

Observe that competition for the franchise leads to rent dissipation. Nevertheless, different cargo handling fees will affect demand and the structure of the shipping market.

4.2 Ex post market structure and welfare

As usual, it is convenient to solve the game by backwards induction. Assume that the outcome of the auction is a cargo handling fee w. The port can choose one of two strategies: operate for volume, $\mathcal{V}$, or underhand integration, $\mathcal{U}$. We begin by analyzing the port's decision and the ensuing market structure. Next we study aggregate welfare in each case.

Market structure Consider first the profits of the port using the $\mathcal{V}$ strategy. Call p^v the price paid by users when the port follows strategy $\mathcal{V}$. Since the shipping market is competitive and low-cost shipping companies will drive high-cost shipping companies out of business, the price paid by users will equal the cost of low-cost shipping companies plus the fee for using the port. Thus, in equilibrium

$$p = s_\ell + w \equiv p^v. \tag{6}$$

The total quantity of cargo handled will be $q^v \equiv q(p^v)$ (where $q(p)$ denotes the demand function, i.e., $D^{-1}(p)$ in the notation of Section 3) and the port will make profits equal to

$$\pi^v(w) \equiv (w - c)q(s_\ell + w). \tag{7}$$

[14]In case of a draw, the winner is determined by lot among those who made the lowest bid.
[15]In case of a draw, the winner is determined by lot among those who made the highest bid.

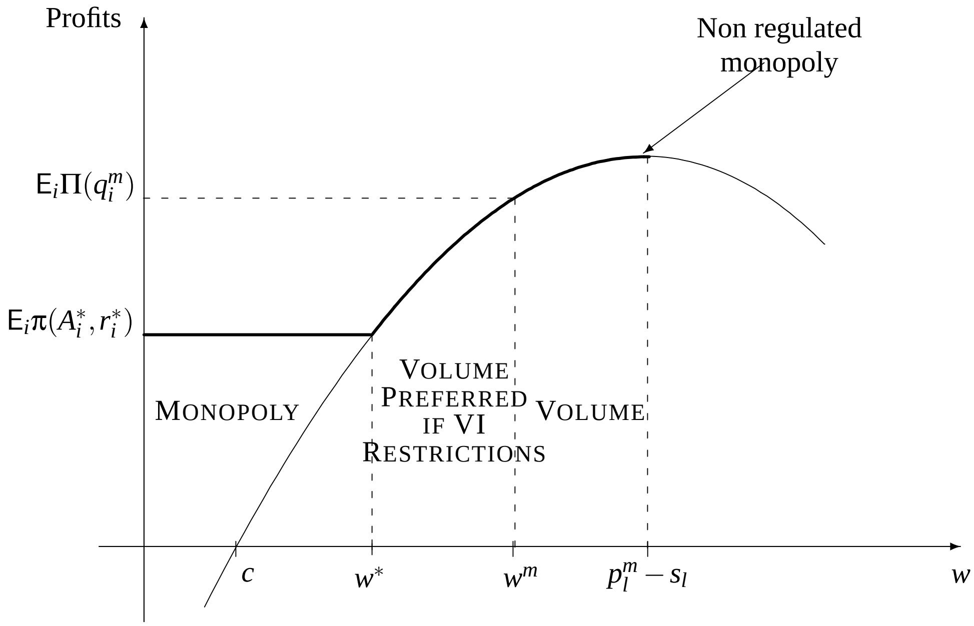

Figure 1: Port profits and market structure

Figure 1 plots the profit function (7), which is continuous and strictly increasing in the relevant range if the standard conditions that ensure strict quasiconcavity hold. $\pi^v(w)$ peaks at $w^m \equiv p^m - s_\ell$, where $p^m = \arg\max\,(p - s_\ell - c)q(p)$, the fee that would be set by an unregulated, vertically separated port. As is well known, the port can exploit all its monopoly power by choosing w such that $w + s_\ell = p^m$.

Now, since $\pi^v(c) = 0$, $\pi^v$is increasing in the interval $[c, p^m - s_\ell]$ and there exists $w^* \in (c, p^m - s_\ell)$ such that

$$\pi^v(w^*) = \mathsf{E}_i\pi(A_i^*, r_i^*),$$

that is, w^* is such that profits from the volume and the underhand strategies are the same. There also exists $w^\iota \in (c, p_\ell^m - s_\ell)$ such that

$$\pi^v(w^\iota) = \mathsf{E}_i\Pi(q_i^\iota) \tag{8}$$

with $w^* < w^\iota$, since $\mathsf{E}_i\pi(A_i^*, r_i^*) < \mathsf{E}_i\Pi(q_i^\iota)$ as shown in the previous section. Note also that $\mathsf{E}_i\Pi(q_i^\iota) < \Pi^\eta(w^m)$ because the expected value considers the possibility of integration with a high-cost firm. The following results are now apparent from Figure 1:

Result 4.1 *When w is close enough to $p^m - s_\ell$ the port prefers volume operations.*

Result 4.2 *If w is sufficiently low, the port will monopolize the shipping market through an underhand agreement.*

Result 4.3 *Vertical separation makes volume operation relatively more attractive.*

Result 4.1 shows that a competitive shipping market ($\mathcal{V}$) is more attractive when the fee w is high. To see the intuition, assume that $w = p^m - s_\ell$. In this case competition weeds out all inefficient shipping companies and the port makes the same profits as an unregulated monopoly. By contrast, if the port chooses to establish an underhand agreement, it must not only share rents and distort production, but it may also pair up with an inefficient shipping company. This makes an underhand agreement less attractive than operating for volume..

If the cargo handling fee w falls, competition in the shipping market transfers more of the efficiency gains to users via lower prices p, but this lowers profits for the port. There is a value of the fee, which we denote by w^*, such that monopolizing the shipping market becomes more attractive, despite the costs of underhand agreements. Interestingly, underhand profits do not depend on w and remain constant at $\mathsf{E}_i\pi(A_i^*, r_i^*)$.

Result 4.3 shows that restrictions on vertical integration enlarge the range of auction outcomes w such that the port chooses the $\mathcal{V}$ strategy and a competitive shipping market results. The reason is quite clear: an underhand integration, even when it cannot be penalized, is not a perfect substitute for legal vertical integration.

Welfare Consider welfare as a function of w. If the port chooses the volume strategy, aggregate welfare is

$$W(q^v) \equiv \int_0^{q^v} D(q)\mathrm{d}q - (c + s_\ell)q^v,$$

i.e., total user surplus minus port and efficient firm shipping costs. Now $d\mathrm{W}(q^v)/dw = [D(q^v) - c - s_\ell]dq^v/dw < 0$ for $w > c$, since $D(q^v) \equiv w + s_\ell > c + s_\ell$ and $dq^v/dw < 0$. On the other hand, with underhand integration, welfare equals $\mathsf{E}_i\mathrm{W}(q_i^*)$. The following proposition compares welfare with competitive and monopolized shipping markets:

Proposition 2 *$W(q^v) > \mathsf{E}_i\mathrm{W}(q_i^\iota) > \mathsf{E}_i\mathrm{W}(q_i^*)$ and $W(q^v) \geq \mathrm{W}(q_i^\iota) \geq \mathrm{W}(q_i^*)$ for $i = \ell, h$. Thus, welfare is always higher when the port chooses a competitive shipping market.*

Proof: Since $d\mathrm{W}(q^v)/dw < 0$ for $w \in [c, p^m - s_\ell]$ and $q^v = q_\ell^\iota$ when $w = p^m - s_\ell$, it follows that welfare with a competitive shipping market is at least equal to $\mathrm{W}(q_\ell^\iota) = \int_0^{q_\ell^\iota} D(q)\mathrm{d}q - (c + s_\ell)q_\ell^\iota$ and generically higher. Now recall that

$$\mathsf{E}_i\mathrm{W}(q_i^\iota) = \lambda\mathrm{W}(q_\ell^\iota) + (1-\lambda)\mathrm{W}(q_h^\iota) > \mathsf{E}_i\mathrm{W}(q_i^*) = \lambda\mathrm{W}(q_\ell^\iota) + (1-\lambda)\mathrm{W}(q_h^*)$$

because $q_\ell^\iota > q_h^*$, from which the result follows. ∎

Proposition 2 implies that vertical and underhand integration reduce welfare. There are three sources of inefficiency when the port chooses underhand integration. First, the standard allocative inefficiency of monopoly, which is also present in an unregulated market (i.e., when the port freely chooses w). Second,

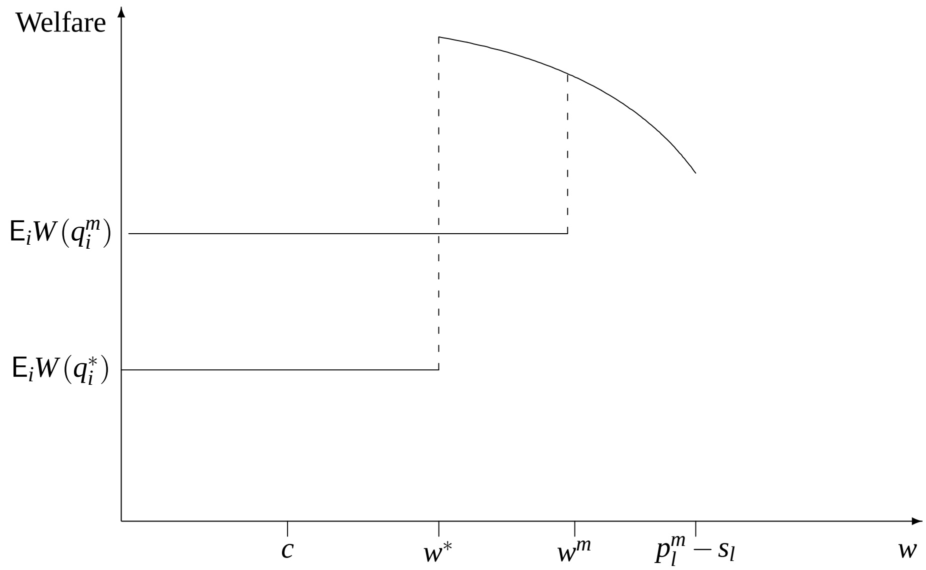

Figure 2: Welfare and market structure

underhand integration leads to productive inefficiency, because a high-cost shipping company may be chosen to monopolize the market. And third, the high-cost firm faces distorted fees in order to lower the cost of the incentive constraint on the low-cost firms.

Figure 2 depicts welfare as a function of the cargo handling fee given the (privately) optimal decision of the port. As long as $w \in [w^*, p^m - s_\ell]$ the port chooses a competitive shipping market when vertical integration is illegal. Welfare increases as we move leftward and w falls; it reaches a maximum when $w = w^*$. The intuition is simple. In that range a lower w leads to a lower shipping fee p and users receive an increasing fraction of the benefits from an efficient shipping market. When the cargo handling fee falls below w^*, the shipping market becomes a monopoly. Welfare jumps down to $\mathsf{E}_i \mathrm{W}(q_i^*)$ and becomes independent of w.

Restrictions on vertical integration have two consequences which differ depending on w. First, they enlarge the range of w's for which the port chooses a competitive shipping market. Obviously, in the interval $[w^*, w^\iota)$ they increase welfare. On the other hand, when the fee is too low, restrictions do not prevent monopolization, so welfare is lower.

4.3 Auction rules, market structure and welfare

The previous sections have shown how the structure of the shipping market and the welfare impact of the restrictions on vertical integration depend on the fee that wins the auction. In this section we examine the auction for the port franchise.

We begin by considering the case where there is no floor (i.e., $\underline{w} = 0$). In this case, $\min_j w_j > 0$ cannot be an equilibrium, for then it pays to set w slightly below $\min_j w_j$ and receive profits which are at least $\mathsf{E}_i \pi(A_i^*, r_i^*) > 0$ if vertical integration is not allowed and $\mathsf{E}_i \Pi(q_i^\iota) > 0$ if it is. Since neither $\mathsf{E}_i \pi(A_i^*, r_i^*)$ nor $\mathsf{E}_i \Pi(q_i^\iota)$ depend on the fee when w is low enough, competition drives $\min_j w_j$ to zero. Moreover, since monopoly profits do not depend on w, $\max_j G_j < \mathsf{E}_i \pi(A_i^*, r_i^*)$ cannot be an equilibrium either. Hence, we have established the following result:

Result 4.4 *(i) If* $\underline{w} = 0$ *and vertical integration is prohibited then in equilibrium* $\min_j w_j = 0$ *and* $\max_j G_j = \mathsf{E}_i \pi(A_i^*, r_i^*)$*; (ii) if* $\underline{w} = 0$ *and vertical integration is allowed then in equilibrium* $\min_j w_j = 0$ *and* $\max_j G_j = \mathsf{E}_i \Pi(q_i^\iota)$.

Result 4.4 shows that in a precise sense competition for the franchise can be too intense. If there is no floor ($\underline{w} = 0$), competition brings w down to the range where monopolization becomes attractive. When $\underline{w} \in [0, w^*)$, the auction leads to a fee of $\underline{w}$ and underhand agreements ensue. Thus, the auction inevitably leads to a monopolized shipping market. While ex ante competition for the franchise extracts all expected rents from bidders, Proposition 2 and Result 4.4 imply the following somewhat surprising corollary, which is apparent from Figure 2:

Corollary 1 *If* $\underline{w} < w^*$*, then (i) welfare is lower than with an unregulated port and (ii) restrictions on vertical integration reduce welfare.*

Simple inspection of Figures 1 and 2 shows that the regulator can do much better by setting a floor $\underline{w} \geq w^*$. Competition for the franchise will drive the cargo handling fee to $\underline{w}$ and the port will choose a competitive shipping market. Any rents that the port may make will be competed away through the lump sum payment G. These facts can be summarized in the following result:

Result 4.5 *(i) If* $\underline{w} \geq w^*$ *and vertical integration is prohibited then in equilibrium* $\min_j w_j = \underline{w}$ *and* $\max_j G_j = \pi^v(\underline{w})$*; (ii) if* $\underline{w} \geq w^\iota$ *and vertical integration is allowed then in equilibrium* $\min_j w_j = \underline{w}$ *and* $\max_j G_j = \mathsf{E}_i \Pi(q_i^\iota)$.

Thus, restrictions on vertical integration can be welfare enhancing when combined with a floor $\underline{w} \geq w^*$, since they allow the regulator to set a lower $\underline{w}$ than without the restrictions. Alternatively, for a given $\underline{w}$, restrictions on vertical integration make it less likely that the shipping market will be monopolized. In any case, Result 4.4 suggests that if there is uncertainty about the true value of w^*, the regulator should err on the safe side by setting a value of the floor $\underline{w}$ above w^*.

A second implication of the preceding results, which is apparent from Figure 1, is that the government obtains a higher lump sum payment if it sets a floor above w^* than when shipping is monopolized through an underhand agreement. For higher floors to the bid there is a tradeoff between revenue and welfare: a higher floor $\underline{w}$ yields more revenue in the auction but decreases welfare. It follows that the revenue generated in the auction is not necessarily a good indicator of welfare.

4.4 A multiperiod extension

Do these results depend on the fact that the port cannot change its partner shipping company, even if it turns out to be a high-cost firm? In the real world, a port that establishes an underhand agreement with an inefficient shipping company will eventually find out the shipping costs and will look for another partner. However, there is no guarantee that the new shipping company will be efficient, so it is possible that the port establishes consecutive agreements with several shipping companies before eventually finding the right partner.

We now show that the solution to this multi-period problem is to offer the same menu of underhand agreements as in the one-period game until the port finds a low-cost shipping company, at which point it establishes a long term agreement and extracts all the surplus in each following period. Interestingly, there is no ratcheting in this case.

The most important result of this section is to show that if there is a cost to switch to another shipping company, the conclusions of this paper continue to hold, and they disappear only when the switching cost disappears altogether, i.e., when there is no disadvantage to an underhand contract, because all cost information is revealed immediately to the port.

Consider the case in which the game is repeated each period, with a large number of periods. In this case the port franchise can offer a contract to the shipping company with the explicit threat of terminating the contract if it turns out to be a high-cost firm. Note that if the firm is a high-cost firm, it behaves exactly as before, lasts one period and the port franchise chooses another firm from the large number of potential firms. If it is a low-cost firm, the port can pay the shipping company enough to make it profitable to reveal its type and then extract all the rent, thus getting the integrated port profits with a low-cost shipping company, $\Pi(q_\ell^\iota)$, each period (Besanko, 1985).[16] Letting V be the expected value of discounted profits, with discount factor δ, we obtain the following Bellman equation:

$$V = \max_{\{A_\ell, A_h, r_\ell, r_h\}} \lambda \left\{ [A_\ell + (r_\ell - c)q_\ell] + \delta \sum_{t=0}^{\infty} \delta^t \Pi(q_\ell^\iota) \right\} + (1-\lambda)\left\{[A_h + (r_h - c)q_h] + \delta V\right\}$$

subject to

$$\begin{aligned}
(p_\ell - s_\ell - r_\ell)q_\ell - A_\ell &\geq 0, \\
(p_h - s_h - r_h)q_h - A_h &\geq 0, \\
(p_\ell - s_\ell - r_\ell)q_\ell - A_\ell &\geq (p_h - s_\ell - r_h)q_h - A_h, \\
(p_h - s_h - r_h)q_h - A_h &\geq (p_\ell - s_h - r_\ell)q_\ell - A_\ell, \\
(p_\ell - s_\ell - r_\ell) + q_\ell D_\ell' &= 0,
\end{aligned}$$

[16] This assumes that all negotiating power lies with the port. In fact, a low cost shipper can threaten to leave if not given a fraction of the rents, and this is costly to the port, which has to start another search for a low cost shipper. Nevertheless, having all rents remain with the port simplifies the exposition and goes against our main point of the relative disadvantage of underhand integration, so the assumption does not bias the results.

$$(p_h - s_h - r_h) + p_h D_h' \quad = \quad 0.$$

Note that the problem facing a shipping company is the same as before, since a low-cost shipping company receives no rent after the first period and a high-cost shipping company is discarded. There is no ratchet effect here because the high-cost shipping company is discarded in the second period, which implies that the low-cost shipping company's payoff after the second period is zero regardless of what it declares in the first period. Hence, the shipping company faces the same incentives and behaves exactly like in the one-period game. It follows that we can replace the values obtained in the one-period game to obtain the modified Bellman equation. Recall that $A_\ell^* = [D(q_\ell^*) - s_\ell - c]q_\ell^* - (s_h - s_\ell)q_\ell^* \equiv \Pi(q_\ell^*) - (s_h - s_\ell)q_\ell^*$ are the profits made by the port when contracting a low-cost firm in the static game and $\Pi(q_h^*) = [D(q_h^*) - s_\ell - c]q_h^*$ are the profits when contracting with a high-cost firm. Replacing in the value function we obtain that

$$V = \lambda \left(\frac{\Pi(q_\ell^*)}{1-\delta} - (s_h - s_\ell)q_h^* \right) + (1-\lambda)[\Pi(q_h^*) + \delta V]$$

which leads to the expression for the value function:

$$V = \frac{1}{1-(1-\lambda)\delta} \left\{ \lambda \left[\frac{\Pi(q_\ell^*)}{1-\delta} - (s_h - s_\ell)q_h \right] + (1-\lambda)\Pi(q_h^*) \right\}.$$

Note that whenever $\delta \neq 1$, there is a loss due to underhand integration and our results remain. It is only when there is no discount of the future, that the value function is dominated by the profits of a low-cost shipping company. It is also interesting to note that whenever $\lambda < 1$, the port franchise cannot extract all profits from the low-cost firm, which can always claim to be a high-cost firm.

5 Conclusions and extensions

We have shown that restrictions on vertical integration can be effective in restraining the exercise of monopoly power over a franchised essential facility, even when the restrictions cannot be enforced. In order for the restrictions to be effective, competition for the franchise must not erode all post-auction rents, because otherwise there is no incentive to operate the port in a competitive fashion and underhand contracts will occur. Moreover, underhand contracts must be less efficient than standard aboveboard contracts. We have shown this result in the context of a standard asymmetric information model, but there are other options. For example, assume away asymmetric information considerations, and consider a model in which the port undertakes sunk investments in equipment that can be used by any shipping company. Observe that while many port assets are sunk and specific, ships are mobile. Since an underhand agreement is by definition an incomplete contract, the shipping company may hold up the port. Then vertical separation reduces the rents obtained by the port because it leads to underinvestment, even when the port can extract all *ex ante* rents by making shipping companies compete to be selected. By contrast, when the shipping market is competitive, a shipping company cannot hold up the port. Hence, vertical separation reduces the relative attractiveness of monopolizing the shipping market.[17]

6 Epilogue

In several decisions, the Chilean appellate and supreme courts decided, partly on the basis of the preceding reasoning, that the arguments of the port authority for restrictions on vertical integration were reasonable, i.e., that the limits to vertical integration would make it less likely that the main ports would be operated by monopoly shipping companies. After the delays caused by the injunctions, the port authority was finally able to proceed with the auction of the main ports. There was a satisfactory number of participants in the bidding process (14 for all ports), including domestic and international firms. The domestic shipping lines participated in joint ventures with foreign specialists in port management.

In all three franchises the floor was attained.[18] These were approximately 10% lower than the rates under the private, multi-operator scheme. The three winning bids were offered by a company which was 40% owned by the shipping company who had been the strongest opponent of restrictions on vertical integration. However, by the rules of the bidding process, the port authority awarded one of the ports (Valparaíso) to the runner up. In the end, the government received US$294 million for the three franchises, twice as much as expected (all participants offered an upfront payment).

Whether the government succeeded in preventing the monopolization of the shipping business in Chile's main ports remains an open question that will be answered by a future evaluation of the franchises' performance. However, the analysis has shown that the restrictions on vertical integration plus a minimum per-unit charge for port operations make it less likely that the winners will operate as port monopolies.

[17] Of course, the difference is larger when it is harder to replace the shipping company.

[18] A fourth franchise for a less important bulk cargo port was also successful. However, in a second round of auctions for smaller local ports, there was less interest: one had no bidder (Arica), while the other had only one bidder (Iquique).

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Appendix

A Proof of Proposition 1

Let $\mathcal{L}$ be the Lagrangian associated to problem (1), and η_i, μ_i and ψ_i, $i = \ell, h$ be the positive multipliers associated with constraints (2), (3–4), (5), respectively.

From the incentive-compatibility constraint (3) and the participation constraint (2) for the high cost shipper it follows that

$$\begin{aligned}(p_\ell - s_\ell - r_\ell)q_\ell - A_\ell &\geq (p_h - s_\ell - r_h)q_h - A_h \\ &> (p_h - s_h - r_h)q_h - A_h \\ &\geq 0.\end{aligned}$$

Hence, the participation constraint of the low-cost shipping company holds with slack and $\eta_\ell = 0$.[19]

Now, from the first order conditions for the A_i, it follows that

$$\frac{\partial \mathcal{L}}{\partial A_\ell} = \lambda - \mu_\ell + \mu_h = 0, \tag{9}$$

$$\frac{\partial \mathcal{L}}{\partial A_h} = (1-\lambda) - \eta_h - \mu_h + \mu_\ell = 0. \tag{10}$$

Solving for λ in (9), then substituting into (10) and rearranging yields $\eta_h = 1$. Hence the participation constraint of the high-cost shipping company binds—all rents are extracted from the high-cost shipping company. Moreover, if $\mu_\ell = 0$ we have $\mu_h = -\lambda < 0$, a contradiction. Hence $\mu_\ell > 0$ and the incentive compatibility constraint for the low-cost firm is binding and the firm is indifferent between behaving as a high- or low-cost firm.

Since η_h and μ_ℓ are strictly positive, we have

$$A_h = (p_h - s_h - r_h)q_h, \tag{11}$$

$$A_\ell = (p_\ell - s_\ell - r_\ell)q_\ell - (s_h - s_\ell)q_h, \tag{12}$$

where $(s_h - s_\ell)q_h$ is the information rent appropriated by the low-cost shipping company.

From (11) it follows that (4) is equivalent to

$$A_\ell \geq (p_\ell - s_h - r_\ell)q_\ell,$$

which by (12) is equivalent to

$$(s_h - s_\ell)(q_h - q_\ell) \geq 0$$

[19] The strict inequality in the derivation above assumes that $q_h > 0$. As will become clear by the end of the proof, this requires that the shipper's optimal q for $r = c + \frac{\lambda}{1-\lambda}(s_h - s_\ell)$ be positive.

and therefore to $q_\ell \geq q_h$. In what follows we ignore this constraint, solve the port's optimization problem and then show that the resulting values of q_ℓ and q_h satisfy the constraint (with strict inequality).

Using (11) and (12) to substitute for A_h and A_ℓ, we can rewrite problem 1 as

$$\max_{(r_\ell, r_h)} \{\lambda[(p_\ell - s_\ell - c)q_\ell - (s_h - s_\ell)q_h] + (1-\lambda)(p_h - s_h - c)q_h\}$$

subject to

$$(p_i - s_i - r_i) + q_i D_i' = 0,$$

$i = \ell, h$. The first order conditions are

$$\frac{\partial \mathcal{L}}{\partial r_\ell} = \lambda[(p_\ell - s_\ell - c) + q_\ell D_\ell'] \frac{\mathrm{d}q_\ell}{\mathrm{d}r_\ell} + \psi_\ell \frac{\partial}{\partial r_\ell}[(p_\ell - s_\ell - r_\ell) + q_\ell D_\ell'] = 0 \tag{13}$$

$$\frac{\partial \mathcal{L}}{\partial r_h} = \left\{(1-\lambda)[(p_h - s_h - c) + q_h D_h'] - \lambda(s_h - s_\ell)\right\} \frac{\mathrm{d}q_h}{\mathrm{d}r_h} + \psi_h \frac{\partial}{\partial r_h}[(p_h - s_h - r_h) + q_h D_h'] = 0. \tag{14}$$

Given s_i, the shipping company's first order condition defines q_i as a function of r_i which, by the second order conditions, is strictly decreasing. It follows that we may differentiate with respect to r_i the first order condition to obtain:

$$\frac{\partial}{\partial r_i}\left\{p_i - s_i - r_i + D_i' q_i\right\} \equiv 0.$$

Now $p_\ell - s_\ell - c = p_\ell - s_\ell - r_\ell + (r_\ell - c)$. Hence, one can rewrite (13) as

$$\lambda(r_\ell - c)\frac{\mathrm{d}q_\ell}{\mathrm{d}r_\ell} = 0$$

where, as mentioned above, $\mathrm{d}q_\ell/\mathrm{d}r_\ell < 0$. Therefore we have $r_\ell^* = c$. Doing a similar substitution for (14) we obtain that

$$[(1-\lambda)(r_h - c) - \lambda(s_h - s_\ell)]\frac{\mathrm{d}q_h}{\mathrm{d}r_h} = 0$$

with $\mathrm{d}q_h/\mathrm{d}r_h < 0$ Hence we have that

$$r_h^* = c + \frac{\lambda}{1-\lambda}(s_h - s_\ell) > c.$$

It now is straightforward to see that $q_\ell > q_h$. Also, trivially, the full information contract that the port would impose is such that the $A_i^!$'s extract all rents and the $r_i^!$'s equal marginal cost c. This concludes the proof of part (a). Part (b) follows from part (a) and the fact that the q_i's are decreasing in the r_i's and $D' < 0$. Last, part (c) follows from the fact that the high-cost shipping company pays a distorted fee per unit of cargo handled and the low-cost shipping company appropriates the information rent.