HOW TO AUCTION A BOTTLENECK MONOPOLY WHEN UNDERHAND VERTICAL AGREEMENTS ARE POSSIBLE

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First version: January 2002
Revised: January 2003

Abstract

In recent years a number of seaport facilities have been awarded in Demsetz auctions to the operator that bidding the lowest cargo-handling fee. A major concern is that the port operator may integrate into shipping and sabotage competitors, thereby rendering the competitive auction irrelevant. The standard policy recommendation to mitigate this problem, is to ban the seaport from operating in the shipping market. Yet such a prohibition may be useless if it can be circumvented by an (illegal) underhand agreement between the port operator and a shipper. In this paper we show that a ban on vertical integration, even when underhand agreements are possible, increases welfare if 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 having no regulation of the bottleneck monopoly.

Our results apply beyond the port and shipping markets, to any monopoly bottleneck that can monopolize a downstream market. The results only require that profits with an underhand vertical agreement be lower than with legal vertical integration.

Key words: Demsetz auctions, monopoly regulation, productive efficiency, sabotage, vertical integration.
JEL classification: D44, L12, L92.

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1 Introduction

In recent years a number of seaport facilities have been awarded in Demsetz auctions to the operator bidding the lowest cargo-handling fee.[2,3] A major concern is that the port operator may integrate into shipping and sabotage competitors, thereby rendering the competitive auction irrelevant.[4] The standard policy recommendation to mitigate this problem, is to ban the seaport from operating in the shipping market. Yet such a prohibition may be useless if it can be circumvented by an (illegal) underhand agreement between the port operator and a shipper. In this paper we show that a ban on vertical integration, even when underhand agreements are possible, increases welfare if 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 having no regulation of the bottleneck monopoly.

In our model the port franchise is awarded in a competitive Demsetz auction. Identical port operators bid both a cargo-handling fee and an up-front payment to the government. The operator bidding the lowest fee wins, but the bid cannot be lower than the floor set by the government. If two or more operators are tied, the port franchise is awarded to the operator that offered the highest up-front payment.[5]

Once in operation, the franchise holder may choose to participate only in the port business; or to vertically integrate into shipping, driving competitors out of business. Vertical integration is inefficient because a monopoly bottleneck that can sabotage competitors is not subject to competitive pressure in the shipping market, which leads to productive inefficiency.[6] Furthermore, and this is central for the paper, banning vertical integration adds to the inefficiency. To see this, note that when integration is legal the port and the shipper become one company, and profits are jointly maximized. By contrast, an underhand agreement involves two separate companies, each maximizing profits individually. Thus, conflicts of interest, which lead to incentive-compatibility constraints, introduce additional inefficiencies. These conflicts of interest may be motivated in

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

[3]Sometimes this is known as "competition for the field" (instead of competition 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 (1985) for a critique). These so called Demsetz auctions have become particularly popular in developing countries, where regulatory institutions are relatively weak.

[4]Sabotage by the port can dissuade non-integrated shippers from using a franchised port. First, by sabotaging the transfer of cargo transported by the non-integrated shipper, companies that need to send cargo through the port may prefer to use the integrated shipper. Second, by slowing the loading and unloading process and by manipulation of the procedure to award slots in the port to arriving ships, it can increase the capital and operational costs for the non-integrated shipper.

[5]If the draw persists, the winner is selected by lot.

[6]On the other hand, there are industries in which vertical integration can result in coordination efficiencies. We do not consider this case, because we are interested in vertical integration whose main purpose is to obtain rents by monopolizing the downstream market. Moreover, Bustos and Galetovic (2003) show that incentives to sabotage are *stronger* with economies of scope.

many ways. One possibility is the inability of making legally binding underhand agreements, which makes it easy to expropriate specific investments. Another is to incorporate heterogeneous and unobservable costs of shipping firms. The seaport must then pay an information rent and distort production to have the shipper reveal her costs. Finally, an illegal agreement may eventually be detected and punished by regulators.

To understand the key roles played by the floor and profit gaps note that the government can set that floor in the auction between zero and the cargo handling fee that allows the port to fully exploit monopoly power; we refer to the latter as the *monopoly fee*. Now, whatever the floor set by the government, the winning fee will equal this floor, since the winner can always choose (legal or illegal) vertical integration and make positive profits by monopolizing the shipping market. It follows that rents are always dissipated via the upfront payment to the government, which equals the maximum expected profits under either integration or separation.

More important, ex post market structure is determined by the floor. On the one hand, if the floor is sufficiently high (e.g. equal to the monopoly fee), the port chooses a competitive shipping market, because it extracts all rents from efficient shippers, avoiding the inefficiencies of vertical integration. By contrast, when the floor is low (e.g. below the port's average cost), the port chooses integration, because monopolizing the downstream market is more profitable.

One implication of the inefficiency of vertical integration is that welfare is higher with an unregulated monopolist than with a Demsetz auction with no floor (or, more generally, with a low floor). In both cases pricing is distorted because the downstream market is monopolized, but a sufficiently high floor (e.g., equal to the monopoly fee) leads to a competitive shipping market, thus avoiding the inefficiencies of vertical integration.

Since profits fall with the fee as long as the port chooses separation, there exists a threshold fee such that the operator prefers separation if the floor is set above, whereas it chooses vertical integration if it is set below. And since profits under integration are lower when such an arrangement is banned, this threshold fee is lower (and closer to average costs) in this case. It is now easy to see that setting the floor equal to the threshold fee is socially optimal, since welfare is always higher with separation and increases as the floor falls, as long as the operator prefers separation. Moreover, it follows from our assumption that profits under illegal integration are lower than under legal integration, that banning vertical integration reduces the threshold and therefore increases welfare.

Central to our result is the assumption that profits for a monopoly port operator with a competitive downstream shipping market are higher than under (legal) vertical integration, which in turn are higher than profits with illegal integration.

Our results apply beyond seaports, to any industry where a potentially competitive segment requires the services provided by natural monopoly bottlenecks (also called *essential facilities*). For example, electricity 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 the bottleneck monopoly, "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 bottleneck monopoly.

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), Riordan and Sappington (1987), Spulber (1989) ch. 9, Laffont and Tirole (1993) ch. 7 and 8, Harstad and Crew (1999) and Engel *et al.* (2001)). We contribute to this literature by studying the interaction between a Demsetz auction and downstream *ex-post* market structure, allowing for the possibility of underhand vertical agreements. 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 downstream market structure.[7] 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. 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 bottleneck monopoly.

Finally, our paper is also related to the literature on vertical integration and sabotage in industries with a regulated bottleneck monopoly (e.g. Beard *et al.* (2001), Economides (1998, 1999), Reiffen (1998), Salop and Scheffman (1983), Sibley and Weisman (1998), Weisman (1995); see Mandy (2000) for a recent survey). We go beyond that literature by allowing underhand vertical agreements when vertical integration is proscribed. Like Beard *et al.* (2001), we find that small margins in the regulated segment stimulate sabotage and vertical agreements. Somewhat in departure to that literature, we find that when a Demsetz auction is used to regulate the bottleneck monopoly, vertical integration and sabotage are unambiguously welfare decreasing when the regulator sets no price floor. The reason is that competition in the auction necessarily drives the bottleneck monopoly's margin to zero when profitable monopolization via sabotage is an option, making it unattractive to sell to efficient downstream firms.

The rest of the paper proceeds as follows. In Section 2 we describe the recent seaport auctions

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

in Chile. This case study motivates some of our assumptions and provides an application of the model. In Section 3 we set up the model, describe the timeline and the types of vertical structures that we compare. In section 4 we compare profits and welfare under the different vertical structures. In section 5, we describe two models in which profits are lower under underhand vertical integration than when vertical integration is allowed. We also describe the multiperiod extension of the model. Section 6 describes the conclusions of the paper. Finally, chapter 7 is an epilogue describing the results of the auctions for seaports in Chile.

2 The Chilean seaport auctions[8]

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 ports can be built, specially close to the main economic center around Santiago. There are no navigable rivers where estuarine ports can be established with calm waters. For this reason, ports require large sunk investments in breakwaters. Consequently, there are only two substantial ports, San Antonio and Valparaíso for general cargo (as opposed to bulk cargo) that are close to Santiago.[9]

It is important to note that once the investments in breakwaters and docks are sunk for a general cargo port, capacity can be increased quite dramatically by adding equipment, without the need to increase the length of the docks or the size of the breakwaters. This means that once a port of this type is built, there are no incentives to build additional general cargo ports in the neighborhood –at least until trade increases sufficiently– and within a range of demand it is an essential facility for the transport of cargo.[10]

Traditionally, Chilean general cargo 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 two main Chilean ports had become congested and the government began to look for alternatives to public funding of additional infrastructure. After consulting with

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

[9]Bulk cargo ports are used for mineral cargo, liquids and grains. They normally do not require large infrastructure investments and in some cases they consist in just a flexible pipeline with a buoy at the end. The ship at anchor connects its own pipe to the port pipeline and unloads or loads liquids. General cargo is usually shipped in containers, and efficient loading and unloading of containers requires specialized gantry cranes sited on the stable platform of a dock. Moreover, ships should be stationary, and this requires calm seas, protected by breakwaters.

[10]There are two ports in the neighborhood of Santiago because the government developed them in the early XXth century, without doing a serious cost-benefit analisis of the need for two ports. On the other hand these are small ports by international standards and if there were only one of them it would be congested –or very close to congestion– even with the best equipment. For engineering reasons expansion of the breakwaters in order to increase the docking area of these two ports is uneconomic.

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

To ensure that productivity improvements would benefit users, 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 the service quality received by 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 the two ports. Second, shipping companies could own not more than 40% of a port operators' equity.[11] In addition, the government fixed a floor for the cargo handling fee. If two or more firms were to bid the floor fee in the auction, the port would be awarded to the firm that offered the highest lump sum payment.[12] It is worth noting that without additional investments in equipment, ports have a limited capacity, so that cartelization is easy between ports that are close to one another and that are similar in most respects (as in the case of Valparaíso and San Antonio, excluding bulk cargo).[13] The volumes transferred by the two ports are given in table 1 and show that both ports are roughly similar in size.

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. We will examine these arguments below. In addition, these firms argued that the two main ports (Valparaíso and San Antonio) are less than 60 miles

[11]These 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.

[12]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.

[13]Given the capacity limitations, a reduction in prices by one port does not displace the other port.

Table 1: Port volumes (2001)

	TEUS[1]	Tons (thousands)
San Antonio[2]	413,900	8,852
Valpararíso	291,403	4,469

: Source `http://www.eclac.cl/transporte/perfil/`.
[1]: Twenty foot equivalent units (standard containers).
[2]: Cargo for San Antonio includes bulk cargo transferred through an independent terminal.

away, and they compete with each other, so there was no danger from monopolization of a port. Note however that port cartelization is fairly easy, as mentioned before, because ports are capacity constrained in the short run, since they require installing specialized equipment before they can increase their capacity substantially.

3 The model

Demand and costs 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 p pays both for shipping and handling a unit of cargo by the port; that is, users pay p to the shipping company, and the shipping company pays the cargo-handling fee to the port (table 2 summarizes the notation).

Shipping firms that operate with (are matched with) a port may match successfully, in which cases shipping costs are low, or they may match unsuccessfully, in which case shipping costs are high. Before starting operations with a port under new management, the shippers do not know the quality of their match. There is a continuum of shipping firms, and we assume that the in the case of good matches, there is a constant average cost of transporting a unit of cargo equal to s_ℓ with probability λ and $s_h > s_\ell$ with probability $1 - \lambda$. Similarly, in the case of a match that escalates into a legal vertical integration arrangement between the port and the shipper, shipping costs are s_ℓ with probability λ and s_h with probability $1 - \lambda$.

The port's average cost of handling a unit of cargo is constant and equal to c and the fee charged for handling a unit of cargo is w. We will assume that the port is able to sabotage –i.e., lower quality– to competitors enough to price any specific shipping company out of the market. There are many identical and risk-neutral potential port operators.

Time line The time line is as follows:

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

2. Each bidder $i = 1, ..., n$ submits a bid $(w_i, G_i) \in \mathrm{IR}^2_+$, where 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 $\min_j w_j$. 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.

4. The port either chooses:

   - A perfectly competitive shipping market and charges $\min_j w_j$ per unit of cargo handled. Call this course of action $\mathcal{C}$ (for "competition").
   - If vertical integration is legal, vertically integrating into shipping. Call this course of action $\mathcal{I}$ (for "integration").
   - If vertical integration is illegal, an underhand vertical agreement with a randomly chosen shipping company, agreeing to a profit sharing scheme (see section 5). Call this course of action $\mathcal{U}$ (for "underhand").

5. If the port chooses $\mathcal{C}$ then:

   - Shipping cost s is revealed to each shipper.
   - Shippers compete.

6. If the port chooses $\mathcal{I}$ then:

   - Shipping cost s is revealed to the port.
   - The port sabotages competitors.
   - The integrated company maximizes profits.

7. If the port chooses $\mathcal{U}$ then:

   - Shipping cost s is revealed to the shipper.
   - The port sabotages competitors.
   - Profit sharing is implemented and the game ends.

Vertical integration and efficiency Assume now that the port chooses $\mathcal{C}$, that is, it leaves shipping to be perfectly competitive. Then, the following result follows:

Result 3.1 *If the shipping market is perfectly competitive, then*

$$p = s_\ell + w \equiv p^c(w). \tag{1}$$

Under competition low-cost shippers drive high-cost shippers out of business. Thus, the cost of shipping a unit of cargo is $s = s_\ell$ and the shipping market achieves productive efficiency. The marginal cost faced by each shipper when using the port, w, is fully passed on to users. Thus, if the port is not regulated it will set w to exploit market power and there will be an allocative inefficiency.

If the port chooses $\mathcal{I}$ and vertically integrates into shipping, it will sabotage competitors and monopolize the shipping market. In addition, its cost is high with probability $1 - \lambda$. Hence,

Result 3.2 *Vertical integration causes a productive inefficiency.*

If vertical integration is banned, and the port establishes an underhand vertical agreement $\mathcal{U}$ with a shipper, it may also be matched to an inefficient shipper. In addition to the productive inefficiency, the agreement with the shipper must be self enforcing. As is well known, incentive-compatibility constraints generally introduce further inefficiencies. We model two sources of such inefficiencies in section 5.

It could be argued that the productive inefficiency of vertical integration and underhand agreements is a construct of our model because s is learnt only after the port integrates into shipping or closes the underhand vertical agreement. If, on the other hand, shippers knew their costs before starting operations, the port could auction the right to become the monopoly shipper and a low-cost shipper would be selected.

Nevertheless, we believe that our assumption is warranted for at least three reasons. First, exclusion via sabotage is usually illegal, independently of the legality of vertical integration. This makes schemes that involve many parties, such as auctions, less attractive because losers in the auction could blow the whistle about sabotage or the underhand agreement. Second, in the real world, a significant number of mergers eventually fail, which suggests that parties do not necessarily know beforehand whether there will be any efficiency gains from the joint operation of the firms. A third and related reason is that our model is an approximation to the case when shippers are unsure about the fit between their equipment and operational procedures and those of the port, and they learn about the quality of their match after they start operations.whether the manner in which the port will be run fits well with their equipment or operation procedures, and they learn their costs after operations begin.[14]

In section 5 we present a multiperiod extension of the model where the port can discard an inefficient match with a shipper after an exogenous time interval in order to try another match. This extension includes a tradeoff between the possibility of achieving a bad match and having to wait –incurring the cost of a bad match– until the port can switch shippers and choosing to operate the port with a competitive shipping market.

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

Unregulated port monopoly with vertical separation The port is free to choose its fee and does not integrate into the shipping market. There is perfect competition among shipping companies and efficient shippers ($s = s_\ell$) drive inefficient ones out of business.

Regulated monopoly with vertical separation: The port charges the tariff it bid in the auction (w) and does not integrate into the shipping market. There is perfect competition among shipping companies.

Legal vertical integration: The port legally integrates into shipping and runs port and shipping to maximize joint profits. It sabotages competitors and monopolizes shipping.

Underhand vertical agreement: Vertical integration is banned but the port establishes an underhand agreement with a randomly chosen shipping company. Thus the port and the shipper remain independent and there is no joint profit maximization. The port sabotages competitors and the shipper monopolizes the market.

4 Auction design

As usual, it is convenient to solve the game by backwards induction. Thus we first take the cargo handling fee w determined in the auction as given and study the possible downstream market structure that can be chosen by the port. Then we study which auction maximizes social welfare.

4.1 Ex post market structure and welfare

Assume that the outcome of the auction is fee w. We begin by analyzing the port's decision and the ensuing market structure. Next we analyze aggregate welfare in each case.

[14] We thank the editor for suggesting this argument.

Table 2: The notation used throughout the paper is the following:

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:	port plus shipping profits
π^u:	port profits with underhand agreement
π^ι:	port profits with legal vertical integration
π^c:	port profits with competition
W:	welfare
w:	open cargo handling fee per unit

SUB AND SUPERSCRIPTS

u:	outcomes with an underhand agreement
ι:	outcomes with a vertically integrated monopoly
c:	competition
ℓ:	low cost
h	high cost
m	monopoly port

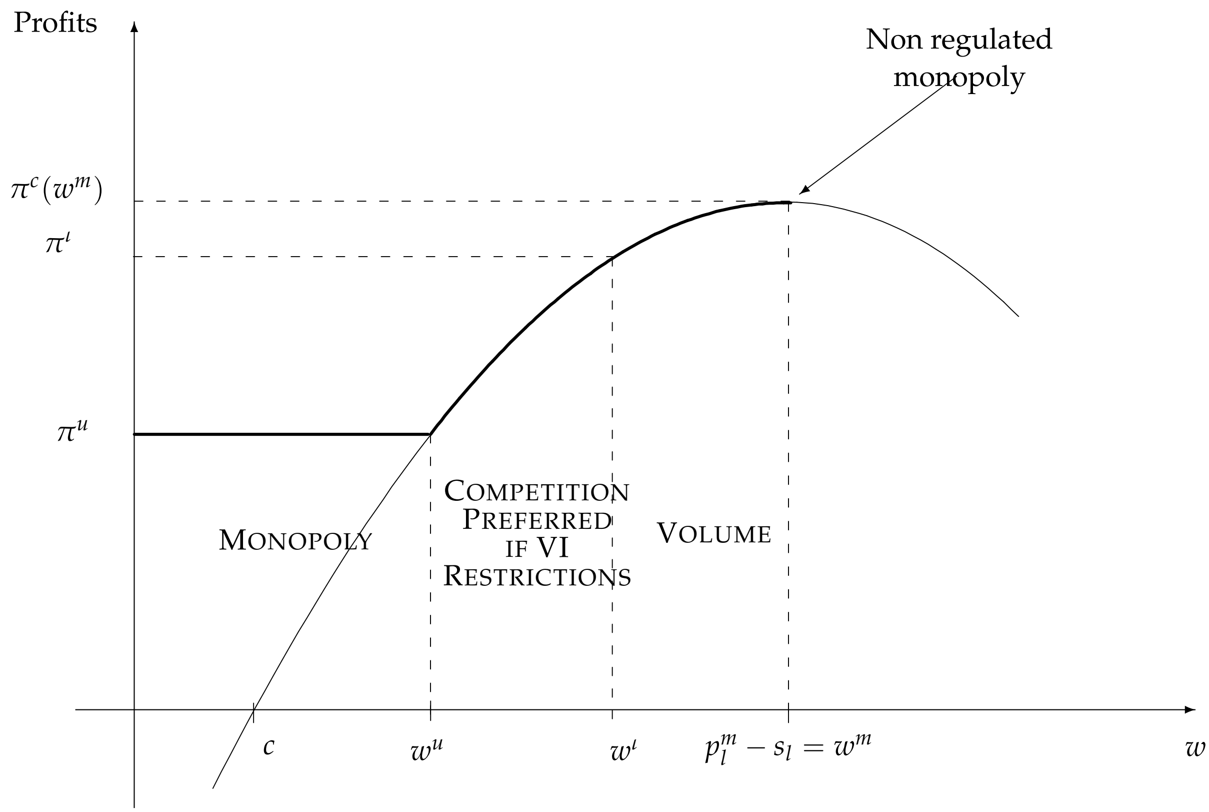


Figure 1: Port profits and market structure as a function of w.

Market structure To begin consider profits if the port chooses $\mathcal{C}$, a competitive shipping market. Then the total quantity of cargo handled will be $q^c \equiv q(p^c)$ (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

$$\pi^c(w) \equiv (w - c)q(s_\ell + w). \tag{2}$$

The thin concave curve in figure 1 graphs port profits π^c as a function of the cargo handling fee w, when the port chooses a competitive shipping market. Profits peak when $w = p_\ell^m - s_\ell \equiv w^m$, the fee that would be set by an unregulated monopoly. The thick curve graphs expected profits as a function of w if the port optimally chooses between $\mathcal{C}$ and $\mathcal{U}$. Port profits with an underhand agreement, π^u, are independent of w.[15] If $w < w^u$ then it is optimal to establish an underhand vertical agreement, which means that expected profits become independent of w. Figure 1 also shows that profits with vertical integration, π^ι, are higher than with an underhand vertical agreement but lower than when the port is not regulated, as shown in result 3.2.

Figure 1 plots the profit function (2), which is continuous and strictly increasing in the relevant range if the standard conditions that ensure strict quasiconcavity hold. $\pi^c(w)$ peaks at $w^m \equiv p^m - s_\ell$, (with $p^m = \arg\max\ (p - s_\ell - c)q(p)$), 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 $w + s_\ell = p^m$.

Next assume that vertical integration is legal and the port vertically integrates into shipping. Then it excludes competitors and monopolizes the shipping market. From the point of view of the integrated firm that maximizes joint profits, the fee w is meaningless, so the profits of the integrated firm, call them π^ι, are independent of w. Given result 3.2, vertical integration leads to productive inefficiency, and these profits are lower than those of an unregulated, vertically separated port monopoly, i.e., $\pi^\iota < \pi^c(w^m)$.[16] Now consider an underhand vertical agreement $\mathcal{U}$. Since it is even less efficient because it adds incentive-compatibility constraints (see the next section), it follows that port profits, π^u, must be even smaller than with open vertical integration. Hence

$$\pi^u < \pi^\iota < \pi^c(w^m).$$

Now, since $\pi^c(c) = 0$ and π^c is increasing in the interval $[c, w^m]$, there exists a *threshold fee* $w^\iota \in (c, w^m)$ such that

$$\pi^c(w^\iota) = \pi^u,$$

that is, w^ι is such that profits from $\mathcal{C}$ and $\mathcal{I}$ are the same. There also exists a threshold fee $w^u \in (c, w^m)$ such that

$$\pi^c(w^u) = \pi^u, \tag{3}$$

with $w^u < w^\iota$, since by the assumption that underhand vertical agreements are costly, $\pi^u < \pi^\iota$. The following results are now apparent from Figure 1:

Result 4.1 *When w is close enough to $p^m - s_\ell$ the port strictly prefers $\mathcal{C}$, a competitive shipping market.*

Result 4.2 *If w is sufficiently low, the port will sabotage competitors and monopolize the shipping market.*

Result 4.3 *A ban on vertical integration lowers the threshold fee from w^ι to w^u.*

[15] They depend on the terms of the underhand agreement, which is independent of the fee w.

[16] Another potential explanation for these inequalities is that sabotage of competitors is illegal, and might be punishable, whether vertical integration is legal or not. (This point was kindly suggested by the editor.)

Result 4.1 shows that a competitive shipping market (c) is more attractive than integration when the fee w is higher than the threshold fee w^ι. To follow 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 monopolize the shipping market, it incurs the inefficiencies of vertical integration. Thus if w is higher than the threshold fee the port prefers competition. 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 such that monopolizing the shipping market becomes more attractive.

Result 4.3 shows that banning vertical integration enlarges the range of auction outcomes w such that the port chooses a competitive shipping market. The reason is quite clear: an underhand agreement is not a perfect substitute for legal vertical integration.

Welfare Consider next welfare as a function of w. If the port chooses a competitive shipping market $\mathcal{C}$, aggregate welfare is

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

i.e., total user surplus minus costs incurred by the port and efficient shippers. Now $d\mathrm{W}^c(w)/dw = [D(q^c) - c - s_\ell]dq^c/dw < 0$ for $w > c$, since $D(q^c) \equiv w + s_\ell > c + s_\ell$ and $dq^c/dw < 0$.

On the other hand, both with legal vertical integration and underhand agreements, welfare is independent of w. Call W^ι welfare with vertical integration and W^u with an underhand agreement. The following proposition characterizes welfare.

Proposition 1 $\mathrm{W}^c(w^m) > \mathrm{W}^\iota > \mathrm{W}^u$. *Thus, welfare is always higher when the port chooses a competitive shipping market $\mathcal{C}$.*

Proof: An unregulated monopoly would charge $w = w^m$, and competition in shipping would ensure productive efficiency. On the other hand, if the port legally integrates, it monopolizes shipping and, in addition, is productively inefficient. It follows that welfare must be lower with legal vertical integration. Moreover, an underhand agreement also leads to monopolization, but is even more inefficient because the agreement must be incentive compatible. Last, $dW(w)/dw < 0$ for $w \in [c, w^m]$, therefore welfare under c.is always higher.∎

Proposition 1 implies that vertical integration and underhand agreements reduce welfare. There are three sources of inefficiency. First, the standard allocative inefficiency of monopoly, which is also present with an unregulated market (i.e., when the port freely chooses w^m and there is competition downstream), but also with integration and underhand agreements. Second, open

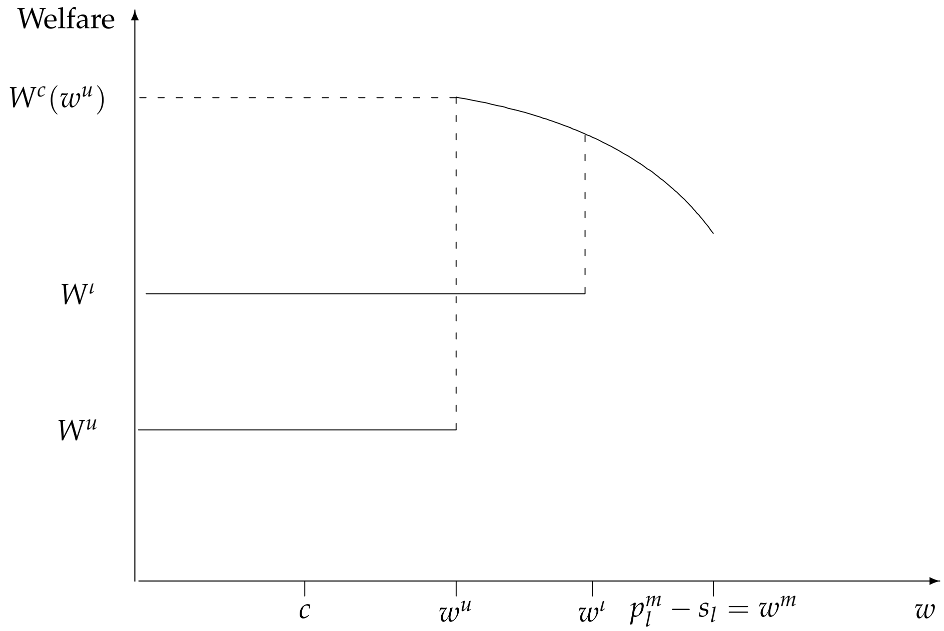


Figure 2: Welfare and market structure

vertical integration adds productive inefficiency. Third, an underhand agreement adds incentive-compatibility constraints to the production inefficiency.

Figure 2 depicts welfare as a function of the cargo handling fee given the (privately) optimal decision of the port. As long as $w \in [w^u, w^m]$ the port chooses a competitive shipping market when vertical integration is banned. Welfare increases as we move leftward and w falls; it reaches a maximum when $w = w^u$. 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^u, however, the port prefers $\mathcal{U}$ and the shipping market becomes a monopoly. Welfare falls to W^u and becomes independent of w. Thus a ban on vertical integration together with a floor at least as high as w^u improves welfare.

Banning vertical integration may increase or decrease welfare, depending on w. On the one hand, it enlarges the range of w's for which the port chooses a competitive shipping market. Obviously, as can be seen from Figure 2, in the interval $[w^u, w^\iota)$ they increase welfare. On the other hand, if w is too low, banning vertical integration would not prevent monopolization and welfare would fall even below W^ι.

4.2 Auction rules, market structure and welfare

We 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 characterize the equilibrium in the auction.

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 $\pi^u > 0$ if vertical integration is prohibited and $\pi^\iota > 0$ if vertical integration is allowed. Since neither π^u nor π^ι 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, $\max_j G_j < \pi^u$ cannot be an equilibrium either. Hence, we have established the following result:

Result 4.4 *(i) If $\underline{w} = 0$ and vertical integration is banned then in equilibrium $\min_j w_j = 0$ and $\max_j G_j = \pi^u$; (ii) if $\underline{w} = 0$ and vertical integration is allowed, then in equilibrium $\min_j w_j = 0$ and $\max_j G_j = \pi^\iota$.*

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. Similarly, when $\underline{w} \in [0, w^u)$, the auction leads to a fee of $\underline{w}$ and an underhand agreement becomes inevitable. Thus, the auction inevitably leads to a monopolized shipping market. While ex ante competition for the franchise extracts all expected rents from bidders, Proposition 1 and Result 4.4 imply the following somewhat surprising corollary, which is apparent from Figure 2:

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

Simple inspection of Figures 1 and 2 shows that the regulator can do much better by setting a floor $\underline{w} \geq w^u$. Competition for the franchise will drive the cargo handling fee to $\underline{w}$ and the port will choose $\mathcal{C}$, 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 $\underline{w} \geq w^u$ and vertical integration is prohibited then in equilibrium $\min_j w_j = \underline{w}$ and $\max_j G_j = \pi^c(\underline{w})$; (ii) if $\underline{w} \geq w^\iota$ and vertical integration is allowed then in equilibrium $\min_j w_j = \underline{w}$ and $\max_j G_j = \pi^c(\underline{w})$.*

Thus, a ban on vertical integration is welfare-increasing when combined with a floor $\underline{w} \geq w^u$, because they allow the regulator to set a lower floor and still avoid the monopolization of the shipping market. Alternatively, for a given floor $\underline{w}$, a ban on vertical integration makes 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^u, the regulator should err on the safe side by setting a value of the floor $\underline{w}$ above w^u.

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^u 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 welfare indicator.

5 The inefficiency of underhand vertical agreements

Our main result in the previous section is that a ban on vertical integration can improve welfare when combined with a floor on the fee that firms can bid in the auction for the port franchise. To derive this result we assumed that underhand agreements added inefficiencies imposed by incentive-compatibility constraints on top of the productive inefficiency of vertical integration . In this section we model two sources of inefficiencies. The first of these stems from heterogeneous and unobservable costs of shipping firms. The second is based on the inability of making legally binding underhand agreements, which makes it easy to expropriate specific investments.

5.1 Cost heterogeneity and adverse selection

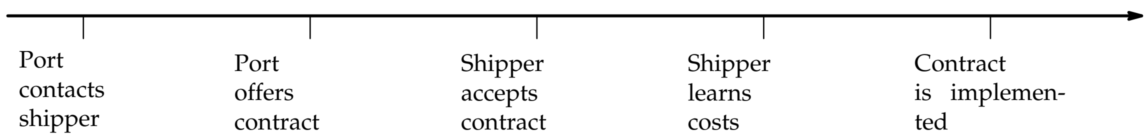
The one-period model As described in section 2, there is a continuum of shippers and each has low cost s_ℓ with probability λ and high cost s_h with probability $1-\lambda$. The port operator approaches a single, randomly chosen shipping company with a take-it-or-leave-it contract. The shipper learns her type after closing the underhand agreement which remains her proprietary information (the time line of the contract is given in figure 3). Nevertheless, because the contract is underhand, we assume that the shipper will abandon it if not profitable.[17] This implies the port must give the shipper her outside option in each of the two states to ensure her participation. For this reason, the port's problem is identical as when the shipper knows her cost before contracting.

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 best the port can do is to offer a menu of contracts

$$A_i + r_i q_i,$$

[17] Mas-Collel *et al.* (1995) uses a different approach: the assumption that the agent is infinitely risk averse, so the principal must offer a contract that guarantees the outside option level of utility. We believe that the approach of reneging on the contract if the shipper receives less than the outside option is more realistic.

Figure 3: Time structure of the underhand game between port and shipper



$i = \ell, h$ where A_i is a fixed amount and r_i is a per-unit fee which is different from the fee w determined in the auction (the notation is summarized in Table 1). The revelation principle implies that the port will maximize its rent by using a direct, incentive–compatible mechanism $(A_i, r_i)_{i=\ell,h}$ to maximize

$$\lambda[A_\ell + (r_\ell - c)q_\ell] + (1-\lambda)[A_h + (r_h - c)q_h] \tag{4}$$

subject to

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

$$(p_\ell - s_\ell - r_\ell)q_\ell - A_\ell \geq (p_h - s_\ell - r_h)q_h - A_h, \tag{6}$$

$$(p_h - s_h - r_h)q_h - A_h \geq (p_\ell - s_h - r_\ell)q_\ell - A_\ell, \tag{7}$$

$$(p_i - s_i - r_i) + q_i D_i' = 0, \quad i = h, l, \tag{8}$$

where $D_i' \equiv D'(q_i)$. The first pair of inequalities (5) represents the two standard participation constraints. As said, the agreement is illegal and the port must ensure the shipping company at least zero profits in each state.[18] The next pair of inequalities, (6) and (7), are standard incentive–compatibility constraints. The last equality (8) appears because the shipping company is free to choose a price that maximizes her monopoly profits given it faces costs $s_i + r_i$.

We assume that λ is low enough so that the port does want to ensure the participation of the high-cost shipper.[19,20] We also assume that there is no recontracting, since the payment of the fixed and variable fees are simultaneous with production. Solving this problem leads to the following result:

[18]Since there is only one match in the game, in principle we have a bilateral monopoly. As is standard in the literature, we allocate all bargaining power to the port. We should stress that this is the worst case scenario for our analysis, since the loss to the port from an underhand agreement is the lowest.

[19]These are contracts directed just at low cost firms, that extract all their rents.

[20]the optimal underhand contract would be identical had we assumed that the shipper knows her type before contracting. To understand why, note that if shippers know their cost when contracting, participation constraints must bind in each cost state. In our model, participation constraints must also bind in each cost state, because we assume that the shipper can always abandon the underhand agreement. Since incentive compatibility constraints are the same in both cases, the optimal truth-revelation contract is the same.

Proposition 2 *Let $(A_i^u, r_i^u)_{i=\ell,h}$ be the contract that solves (4)–(8); let $(p_i^u, q_i^u)_{i=\ell,h}$ be the corresponding quantities and prices chosen by the shipping company and $\Pi(q_i^u)$ the combined profits. Moreover, let $(A_i^\iota, r_i^\iota)_{i=\ell,h}$ be the full-information contract, 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 (that is the port's plus the shipper's). Then*

1. $r_\ell^u = c = r_\ell^\iota$ *and* $r_h^u = c + \frac{\lambda}{1-\lambda}(s_h - s_\ell) > c = r_h^\iota$;
2. $p_\ell^u = p_\ell^\iota$ *and* $p_h^u > p_h^\iota$;
3. $A_\ell^u < \Pi(q_\ell^u) = \Pi(q_\ell^\iota) = A_\ell^\iota$ *and* $A_h^u + (r_h^u - c)q_h^u = \Pi(q_h^u) < \Pi(q_h^\iota) = A_h^\iota$.

Proof: See Appendix A. ∎

Note that the full-information contract $(A_i^\iota, r_i^\iota)_{i=\ell,h}$ would replicate the outcome obtained with legal vertical integration (hence the superscript ι). If the port could vertically integrate into shipping it would expand operations until the marginal increase in volume, which produces revenue $p_i + q_i D_i'$, equals the marginal increase in costs, $c + s_i$. Since $r_i^\iota = p_i^\iota - s_i$, we have $c = s_i$, i.e., there are no productive inefficiencies.

However, Proposition 2 shows that the ban on vertical integration reduces port profits for two reasons. First, when the shipper is high-cost the port sets a per-unit charge of $r_h^u > c$, which distorts (optimally) the decisions of the high-cost shipper. The distortion increases as λ increases (see part 1 of Proposition 2). Second, when the shipper has low cost $r_\ell^u = c$, it does not face a distortion. Nevertheless, to ensure truthful revelation the port must provide an information rent to the shipper. Since $s_h > s_\ell$ and $(p_h^u - s_h - r_h^u)q_h^u - A_h^u = 0$, the low-cost shipper could make a profit

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

by claiming that its cost is high. This sets a lower bound on the rent that the low-cost shipper receives.

It can now be seen why the distortion imposed on the high-cost shipper falls with λ, the ex ante probability of a shipper being low-cost. When designing the optimal contract the port faces the following trade off: it can pay a smaller (but incentive-compatible) information rent to the low-cost shipper at the cost of worsening the contract offered to the high-cost shipper. For example, at one extreme, it could set r_h^u high enough to price the high-cost shipper out of the market, which would allow him to leave no information rent in the pockets of the low-cost shipper. At the other extreme, it could set $r_h^u = c$, but this would force him to give a large information rent to the low-cost shipper. Thus the optimum distortion depends on λ. If λ is close to 0, then there is a high probability that the will be matched to a high-cost shipper, and it pays to distort little in the high-cost state and pay a large information rent in the unlikely event that the shipper is low-cost; on the contrary, if λ is close to 1 then the distortion should be large and the information rent small.[21]

We can now check whether $\pi^u < \pi^\iota$. The port's expected profits when vertical integration is banned and the port closes an underhand agreement $\mathcal{U}$ are

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

where $\pi(A, r)$are the port's profits with an underhand agreement such that the fixed fee A and the per-unit fee is r. These profits are lower than the profits of a vertically integrated port, viz.

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

since $A_\ell^u < \Pi(q_\ell^\iota)$ and $\Pi(q_h^u) < \Pi(q_h^\iota)$, as shown in Proposition 2.

It is also useful to compare aggregate welfare with vertical integration and an underhand agreement. Let $\mathrm{W}(q)$ be aggregate welfare when q units of cargo are handled, then

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

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 $\mathsf{E}_i\mathrm{W}(q_i^u) < \mathsf{E}_i\mathrm{W}(q_i^\iota)$ since $q_h^u < q_h^\iota$. Moreover, when the port is matched to a low cost shipping company, aggregate welfare under vertical integration equals welfare under an unregulated monopoly and competition in the shipping market.

A multiperiod extension As is standard, we assumed that the port credibly commits to honour the underhand agreement. Nevertheless, the port may want to renegue on the contract with the shipper and discard the shipper after she has made the lump-sum payment A; or to seek another partner after the high cost shipper reveals her cost. Reneguing on the contract may not be costless: finding another partner may take time (there is no guarantee that the next shipper will be low-cost), and, moreover, the cheated shipper may blow the whistle about sabotage and underhand agreements.

To model the possibility that the port can renegue at some cost we assume that it must wait a period of exogenous and arbitrary length τ to change the shipper with whom it established an underground agreement. Now assume that the port acts as follows. At $t = 0$ the port offers an

[21]Of course, this result is standard in the literature. See, for example, Dixit (1990, example 9.2).

underhand contract $(A_i, r_i)_{i=\ell,h}$, which lasts until τ. If the shipper is revealed to have low-costs, the port establishes a long-term agreement with the same shipper at $t = \tau$ and extracts *all* the surplus in each following period (clearly this is optimal if information is symmetric and the port has all the bargaining power).[22] If, on the other hand, the shipper is high-cost, the port has to wait until $t = \tau$ in order to discard the shipper and offer the same menu to another shipper; this process goes on until the port finds a low-cost shipper. Note that, as in Besanko (1985), the high-cost shipper will behave exactly as in the one-period model, because she has a one-period horizon before she is discarded. On the other hand, as long as the contract $(A_i, r_i)_{i=\ell,h}$ is incentive-compatible, the low-cost shipper will reveal her information, because it cannot gain by lying since acting as a high cost shipper implies that she will be discarded in the next period: incentive compatibility makes her indifferent between telling her true costs and lying about them.

As before let $(A_i, r_i)_{i=\ell,h}$ be the underhand contract offered by the port, but interpret it now as an instantaneous flow which is received during a period of length τ. A assuming that the continuous interest rate is ρ, the present value of the port's payoff if matched with a low-cost shipper is

$$\int_0^\tau [A_\ell + (r_\ell - c)q_\ell]e^{-\rho t}\mathrm{d}t + \int_\tau^\infty \Pi(q_\ell^\iota)e^{-\rho t}\mathrm{d}t = \frac{1}{\rho}\left\{(1-\delta)[A_\ell + (r_\ell - c)q_\ell] + \delta\Pi(q_\ell^\iota)\right\},$$

with $\Pi_\ell \equiv \Pi(q_\ell^\iota)$ and $\delta \equiv e^{-\rho\tau}$; that is, during the first period the port uses the separating contract and from then on extracts all surplus from the low-cost shipper. Letting V be the expected value of discounted profits with discount factor δ, we obtain the following Bellman equation:

$$V \equiv \max_{\{A_\ell, A_h, r_\ell, r_h\}} \frac{1}{\rho}\left\{\lambda\left[(1-\delta)[A_\ell + (r_\ell - c)q_\ell] + \delta\Pi(q_\ell^\iota)\right] + (1-\lambda)[(1-\delta)[A_h + (r_h - c)q_h] + \delta V]\right\}$$

subject to

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

[22] This assumes that the port has all bargaining power. 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, as we have mentioned before, giving all bargaining power to the port goes against our main point of the relative disadvantage of underhand integration, so the assumption does not bias our conclusions.

As before, with probability λ the port closes an underhand agreement with a low-cost shipper. With probability $1-\lambda$ the shipper is high cost, in which case the agreement lasts only one period of length τ. The expected value of discounted profits is then V again.

Note that from the point of view of the shipper the problem looks the same as before: if the shipper is low-cost it receives no rent after the first period and if high-cost it will be discarded. For this reason, there is no ratchet effect. Because the high-cost shipper is discarded in the second period, the low-cost shipping company's payoff after the second period is zero regardless of her first-period cost declaration. Hence, the shipping company faces the same incentives and behaves exactly as 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 $A^u_\ell = [D(q^u_\ell) - s_\ell - c]q^u_\ell - (s_h - s_\ell)q^u_\ell \equiv \Pi(q^u_\ell) - (s_h - s_\ell)q^u_\ell$ are the profits made by the port when contracting a low-cost firm in the static game and $A^u_h = [D(q^u_h) - s_h - c]q^u_h \equiv \Pi(q^u_h)$ are the profits when contracting with a high-cost firm. Replacing into the value function we obtain

$$V = \frac{\lambda}{\rho}\left[(1-\delta)[\Pi(q^u_\ell) - (s_h - s_\ell)q^u_\ell] + \delta\Pi(q^\iota_\ell)\right] + \frac{(1-\lambda)}{\rho}(1-\delta)\Pi(q^u_h) + (1-\lambda)\delta V]$$

which leads to the expression for the value function:

$$V = \frac{\rho^{-1}}{1-(1-\lambda)\delta}\left\{(1-\delta)[\lambda[\Pi(q^u_\ell) - (s_h - s_\ell)q^u_\ell] + (1-\lambda)\Pi(q^u_h)] + \lambda\delta\Pi(q^\iota_\ell)\right\},$$

Note that as $\tau \to \infty$ (the port can never discard the shipper), $\delta \to 0$ and

$$\rho^{-1}[\lambda[\Pi(q^u_\ell) - (s_h - s_\ell)q^u_\ell] + (1-\lambda)\Pi(q^u_h)];$$

hence we replicate the one-period model. It is only when periods become very short ($\tau \to 0$) that $\delta \to 1$ and V tends to

$$\rho^{-1}\Pi(q^\iota_\ell);$$

the value function is dominated by the profits of a low-cost shipping company, $\Pi(q^\iota_\ell)$. The reason is obvious: in the limit, when $\tau \to 0$, the port discovers the type of the shipper immediately and can switch instantaneously to another shipper, so the loss before finding an efficient shipper is zero.

The most important conclusion is that whenever there is a cost to switch to another shipping company (in this case, given by the time to switch), the main conclusions of the imperfect information model continue to hold, and they disappear only when the switching cost disappears altogether, i.e., when all cost information is revealed immediately to the port. This also shows that the relevance of this example rests on the assumption that changing the shipper takes a non-trivial amount of time (τ is not "too small").

5.2 Specific investments and shipper's opportunism

Assume again that there are high- and low–cost shippers, and that efficient operations require investments in the port which are specific to each shipper. While many port assets are sunk and specific, ships are obviously mobile. Since an underhand agreement is by definition an incomplete contract, the shipping company may hold up the port, by threatening to leave unless its demands are satisfied, in which case, there is a probability $1-\lambda$ (or λ) that the investments are inappropriate for the next shipper with which the port tries to establish an underhand agreement. This implies that vertical separation (induced by the restriction on vertical integration) reduces the port's rent because it leads to underinvestment. When the port is allowed to vertically integrate into shipping, it may still be the case that its costs are high, so even though investment is efficient, productive inefficiency remains. If the port chooses a competitive shipping market, it invests in facilities appropriate for low–cost shippers. Of course, as in the previous example, the relative attractiveness of the different options depends on the cost of switching shippers under either type of vertical integration.

Assume that, as before, the marginal cost of handling a unit of cargo is constant, but it is a function of the amount invested by the port in site-specific assets. Thus, marginal cost is a function $c(I_i)$, with $c' > 0$, $c'' > 0$, where I_i is the amount invested in type $i = \ell,\ h$ capital. We assume that investment in type i capital is useless for a type $j \neq i$ shipper. To simplify the analysis, we assume that there is symmetric information.

Assume that the port invests I_i. Then ex-post total profits are

$$\Pi_i = [p - s_i - c(I_i)]q.$$

Clearly, regardless of how Π_i is shared, it is optimal to set q equal to the monopoly quantity. Moreover, since the contract is incomplete, any *ex ante* sharing agreement is irrelevant. Thus we assume that after bargaining ex post the port captures a fraction $\alpha \in (0,1)$ of Π_i. Then, whenever it is matched to a type i shipper, it will invest

$$\max_{I_i} \alpha[D(q) - s_i - c(I_i)]q - I_i, \tag{9}$$

Solving this problem leads to the following result:

Proposition 3 *Let I_i^u be the level of investment that maximizes (9) and $\pi_i(I_i^u)$ the corresponding combined profits. Moreover, let I_i^ι be the level of investment that would had been chosen by a vertically integrated port (i.e., no opportunism) and $\pi_i(I_i^\iota)$ the corresponding combined profits. Then*

(a) $I_i^u < I_i^\iota$;
(b) $\Pi_i(I_i^u) < \Pi_i(I_i^\iota)$.

Proof:

Since q is chosen optimally for each I_i, the envelope theorem implies that the first order condition of problem (9) is

$$-c'(I_i^u)q(I_i^u) = \frac{1}{\alpha}.$$

Now q and $-c'$ are decreasing in I_i (the optimal monopoly quantity increases when costs fall and $c'' > 0$). Moreover

$$-c'(I_i^\iota)q(I_i^\iota) = 1.$$

Hence, $I_i^u < I_i^\iota$.

Part (b) follows trivially by noting that $I_i = I_i^\iota$ maximizes $[D(q) - s_i - c(I_i)]q - I_i$. ∎

Note that since the port has bargaining power ex ante, it will demand a payment from the shipping company. This payment can be at most $A_i^u = (1-\alpha)[D(q^u) - s_i - c(I_i^u)]q^u$ with $q^u = q(I_i^u)$. Thus, its expected utility is at most

$$\lambda \left\{[D(q_\ell^u) - s_\ell - c(I_\ell^u)]q_\ell^u - I_\ell^u\right\} + (1-\lambda)\left\{[D(q_h^u) - s_h - c(I_h^u)]q_h^u - I_h^u\right\}$$

This expected payoff is less than what the port would obtain if vertically integrated, viz.

$$\lambda \left\{[D(q_\ell^\iota) - s_\ell - c(I_\ell^\iota)]q_\ell^\iota - I_\ell^\iota\right\} + (1-\lambda)\left\{[D(q_h^\iota) - s_h - c(I_h^\iota)]q_h^\iota - I_h^\iota\right\}.$$

Thus an underhand agreement is less attractive, which implies that a competitive shipping market $\mathcal{C}$ becomes relatively more attractive, and therefore requires a lower minimum price in the Demsetz auction.

6 Conclusions

We have shown that banning vertical integration can help to restrain the exercise of monopoly power over a franchised bottleneck monopoly, even when the restrictions are not actively enforced. But to be effective, competition for the franchise must not erode all post-auction rents, because otherwise there is no incentive to operate the port competitively and then underhand agreements become more attractive. We have shown this result in the context of a standard asymmetric information model, as well as in a model of specific investments and opportunism.

There are other reasons why underhand agreements are less efficient than vertical integration. For example, consider a model in which there is a positive possibility of detection of the underhand agreement, in which case, the port is punished. This makes underhand agreements relatively less attractive and our previous argument implies that vertical separation and competition can be achieved with a lower floor in the Demsetz auction, increasing welfare.

7 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, including domestic and international firms. The domestic shipping lines participated in joint ventures with foreign specialists in port management.

The main franchises offered for bidding were Valparaíso and San Antonio, and in both cases the minimum fees were attained.[23] The minimum fees 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 franchises sold in the first round, twice as much as expected (all participants offered an upfront payment).

The results of privatization have been impressive: investment in specific equipment and software increased surged, and transfer speeds increased substantially, as can be seen for the case of the the Puerto of Valparaíso in table 3. Similarly, in two years (1999-2001), the speed of operations in the franchised section of Chile's main port, San Antonio, went up from 475 to 635 tons/hour, an increase of 34%. Interestingly, the increased competitiveness of the auctioned port terminals have led the operators in the non-franchised sections of the ports to invest in equipment. Therefore, transfer speeds have increased substantially in both the franchised and non-franchised terminals at each port.

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

[23]Two other relatively important franchises were also successful. However, in a second round of auctions for smaller local ports, there was less interest: one was deserted (Arica), while the other had only one bidder (Iquique).

Table 3: Valparaíso: Time spent in loading and unloading (U/L) and transfer velocity

	1999	2001	2002 (est.)
U/L Time (hrs)	45.0	26.3	21.0
Productivity (containers/hr)	25.5	43.7	54.8

Source: Empresa Puerto Valparaíso. Loading and Unloading time refers to a Eurosal vessel with 1150 cargo movements.

of the franchises' performance. However, our 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.

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Appendix

A Proof of Proposition 1

Let $\mathcal{L}$ be the Lagrangian associated to problem (4), and η_i, μ_i and ψ_i, $i = \ell, h$ be the positive multipliers associated with constraints (5), (6–7), (8), respectively.

¿From the incentive-compatibility constraint (6) and the participation constraint (5) 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 $\eta_\ell = 0$.[24]

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

$$\frac{\partial \mathcal{L}}{\partial A_\ell} = \lambda - \mu_\ell + \mu_h = 0, \tag{10}$$

$$\frac{\partial \mathcal{L}}{\partial A_h} = (1-\lambda) - \eta_h - \mu_h + \mu_\ell = 0. \tag{11}$$

Solving for λ in (10), then substituting into (11) 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

$$A_h = (p_h - s_h - r_h)q_h, \tag{12}$$

$$A_\ell = (p_\ell - s_\ell - r_\ell)q_\ell - (s_h - s_\ell)q_h, \tag{13}$$

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

From (12) it follows that (7) is equivalent to

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

[24] 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.

which by (13) is equivalent to

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

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 (12) and (13) to substitute for A_h and A_ℓ, we can rewrite problem (4) 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

$$\frac{\partial \mathcal{L}}{\partial r_\ell} = \lambda[(p_\ell - s_\ell - c) + q_\ell D_\ell'] \frac{\mathrm{d}q_\ell}{\mathrm{d}r_\ell} + \psi_\ell \frac{\partial}{\partial r_\ell}[(p_\ell - s_\ell - r_\ell) + q_\ell D_\ell'] = 0 \tag{14}$$

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial r_h} &= \left\{(1-\lambda)[(p_h - s_h - c) + q_h D_h'] - \lambda(s_h - s_\ell)\right\} \frac{\mathrm{d}q_h}{\mathrm{d}r_h} \\ &\quad + \psi_h \frac{\partial}{\partial r_h}[(p_h - s_h - r_h) + q_h D_h'] = 0. \end{aligned} \tag{15}$$

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 (14) 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 $r_\ell^u = c$. Doing a similar substitution for (15) 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

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

It now is straightforward to see that $q_\ell^u > q_h^u$. Also, trivially, the full information contract that the port would impose is such that the A_i^ι's extract all rents and the r_i^ι's equal marginal cost c. This concludes the proof of part (1). Part (2) follows from part (1) and the fact that the q_i's are decreasing in the r_i's and $D' < 0$. Last, part (3) 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.