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# Unionised dockworkers and port ownership structure in an international oligopoly

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## Abstract

In an international duopoly with two markets and two ports, this paper investigates the role of dockworkers unionisation in affecting welfare outcomes under public and private ports, as well as in determining the endogenous choice by governments of port ownership structure. While private ports maximise profits, public ports maximise domestic welfare and face a budget constraint, which is binding when unions are sufficiently wage-oriented and shipping costs are not too high. Consumer surplus, total wage bill and domestic welfare are generally higher under public ownership, especially when unions are wage-oriented. The opposite holds true for firm profits, whilst privatisation always increases port profits. Moreover, relative to endogenous port ownership structures, state-owned ports appear as the most likely equilibrium result although all possible configurations may arise in equilibrium, including an asymmetric structure with a state-owned port and a private port.

JEL Codes: F16; J51; L33; R48

Keywords: unionised dockworkers; port ownership structure; international duopoly; welfare outcomes

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# 1 Introduction

Despite the progressive shift towards a capital-intensive paradigm, the human factor remains one of most valuable assets in the port domain and seaports still represent important job generators (Satta et al., 2019; Bottalico, 2022; Bottalico et al., 2022). Port workers, also referred to as *dockworkers*, are employed by a variety of employers –private terminal operators, public port authorities (especially crane drivers) or by companies controlled by a state-owned entity– and are involved in all forms of cargo handling in a port zone, including the stuffing and stripping of containers, the loading and unloading of inland waterway vessels, lorries, and railway wagons, and the storage and semi-industrial processing of goods in warehouses and logistics areas (e.g., Van Hooydonk, 2014; Notteboom et al., 2022).<sup>1</sup>

Trade or labour unions are the principal institution of workers in modern capitalist economies, playing a key role on the functioning of labour markets (e.g., Freeman and Medoff, 1984; Calmfors and Driffill, 1988; Freeman, 1988; Layard and Nickell, 1999). Historically, labour unions have worked to advocate dockworkers’ interests and, although major differences in union power and representativeness can be observed across countries and seaports, they are significantly visible at the dock labour front. Indeed, the port labour pool typically includes highly unionised workers, who are considered to be among the most militant, across time and space (e.g., Notteboom, 2010; Ahlquist et al., 2014).<sup>2</sup>

Ports and port workers have always been involved in international trade, insofar as they handle their country’s maritime imports and exports (e.g., Trujillo and Nombela, 1999;

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<sup>1</sup>Typically, the term “port worker” or “dock worker” is used to identify these workers. Cargo handling companies also employ office staff in administration, sales, marketing, information technology, legal etc.. However, white collar employees are generally not considered to be “dockers” or “port workers” (Van Hooydonk, 2014).

<sup>2</sup>In their seminal analysis of inter-industry differences in strike-proneness, Kerr and Siegel (1954) concluded that dockers together with seamen and miners were the most strike-prone groups. Notteboom (2010) points out that in many European countries dock labour unions enjoyed elevated membership and well-established collective bargaining rights. Ahlquist et al. (2014) provide evidence that ILWU (International Longshore and Warehouse Union) membership (and available work) has increased from 1995 onward.

González and Trujillo, 2008). Furthermore, the governance of ports has changed dramatically over the last few decades and, starting from the 1980s, private sector investment and involvement in ports has emerged as a significant issue (e.g., Rodal and Mulder, 1993; Trujillo and Nombela, 1999; Baird, 2000; Brooks, 2004; Midoro et al., 2005; Tongzon and Heng, 2005). In particular, many ports around the world have been moving away from a completely public ownership and management model (the so-called “*public service*” port), in which the government owns the port infrastructures and superstructures, and employs the port labour, to other ownership structures and organizational models, which provide for an ever-increasing role for private companies and operators.<sup>3</sup>

Institutional reforms to privatisation of this kind have far reaching effects on workers and unions, who are obliged to face a number of crucial challenges to adjust and optimize their own effectiveness when dealing with reform (e.g., The World Bank, 2007). Accordingly, a proper and overall evaluation of port privatisation reforms on port profits and national welfare cannot disregard the role of unions in determining dockworkers’ wages,<sup>4</sup> nor the effects of privatisation on dockworkers’ welfare.

The objective of this work is twofold. First, it aims at investigating how the role of labour unions in setting dockworkers’ wages can affect the determination of port usage fees and, as a result, economic performance, and how this relates to the ownership structure of the port. Secondly, in the presence of unionised dockworkers, it compares national welfare outcomes under alternative port ownership structures and analyses governments’ (endogenous)

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<sup>3</sup>Ownership and management models that combine public and private participation in port activities include “*tool*” ports, where all the port infrastructures and superstructures are publicly owned, whilst some services, especially cargo handling, are provided as concessions to the private sector to run, and “*landlord*” ports, in which the Port Authority acts as regulatory body and as landlord, while port operators are carried out by private companies. Finally, even if less common, there is also a fully privatised port model (mainly in the UK and New Zealand), in which ownership of port land, as well as that of all infrastructures and activities is transferred by the government to private entities.

<sup>4</sup>Wages and other labour costs represent a significant part of port operation costs. According to the ITF (International Transport Workers’ Federation), they are estimated between 30-70 percent of the cost of operating a terminal, depending on the terminal type (ITF, 2004).

incentives to privatise their ports.

The analysis clarifies the interplay between the setting processes of dockworkers' wages and port usage fees. This also enables us to identify a new perspective of the effects of ownership structure on the determination of port usage fees, which refers to the important role played by budget constraints in public institutions. Indeed, public ports (like other public firms), which aim to maximise domestic welfare (instead of profits), may be restricted in their choices by the fact that they possess a limited amount of resources.<sup>5</sup> The budget constraint, whenever binding, leads the public port to increase its usage fees. At the same time, considering the negative effect of such an increase on port employment, the presence of a budget constraint can actually be welfare-enhancing by inhibiting the union from becoming overly wage-aggressive.

In public ports, the budget constraint proves to be binding when unions are sufficiently wage-oriented and shipping costs are not too high. Indeed, high shipping costs discourage firms from exporting goods and reduce port activity and employment, which drives unions to put a brake on their wage claims. This leads to a situation in which wages are generally larger in public ports, unless unions are strongly wage-oriented or shipping costs are high.

With reference to port usage fees, they are generally higher under private ownership unless shipping costs are sufficiently high. However, as unions become more wage-oriented, the threshold on shipping costs, above which usage fees are larger under public ownership, increases, making the latter event increasingly less likely. On the one hand, when the (public port) budget constraint is binding because unions are distinctly wage-oriented (hence wages *ceteris paribus* are high), public ports would opt to set lower fees yet are forced to fix them exactly equal to wages. Instead, private ports can freely choose usage fees to maximise their profits, which leads them to set fees higher than wages. On the other hand, when the budget

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<sup>5</sup>As specified in the *Port pricing* report by the United Nations “[t]he first port-pricing constraint is the need to cover, through port charges, the costs which are incurred by the port entity. In effect, since the flow of costs represents financial obligations, the port entity will need to obtain a flow of income to enable it to discharge these obligations [...] the flow of revenue must be at least equal to the flow of costs.” (United Nations, 1975, p. 8).

constraint is not binding, usage fees in public ports do not depend on wages; by contrast, they increase with wages in private ports. As a result, as unions become more wage-oriented, the possibility that port usage fees are higher under public ownership is sharply reduced.

Moreover, by affecting goods sold abroad and at home, usage fees also drive the comparison of welfare outcomes (consumer surplus, profits, total wage bill and overall domestic welfare) under alternative ownership structures. Specifically, consumer surplus, total wage bill and domestic welfare are generally higher under public ownership, especially when unions are wage-oriented. The opposite holds true for firm profits, whilst privatisation always increases port profits. Such results add to those obtained by the received literature and suggest that taking the role of dockworkers and unionised wage setting into account enhances the social desirability of a public port ownership structure.

Finally, with reference to the endogenous choice by governments of the port ownership structure, all the possible ownership configurations, including an asymmetric structure with a state-owned port and a private port, can arise in equilibrium, depending on the union orientation towards wages with respect to employment (which can also capture the union's relative bargaining power *vis-à-vis* its port) and shipping costs. Still, the public ownership structure, in which both ports are state-owned, appears to be the most popular, that is, the one that arises for most combinations between the structural parameters. More specifically, a unique equilibrium in which both ports are state-owned arises in particular when unions are wage-oriented or shipping costs are high enough. Instead, a unique equilibrium in which both ports are privatised will arise only when unions are employment-oriented and shipping costs are sufficiently, but not excessively, low. Furthermore, multiple equilibria with symmetric and asymmetric ownership choices may also emerge, especially when unions are not distinctly wage-oriented and shipping costs are not too high.

The remaining part of the paper is organised as follows. Section 2 describes the contribution of this work with respect to the received literature. In Section 3, the basic framework is introduced and equilibrium outcomes relative to dockworker wages, port usage fees and firm output (which also drive those on welfare outcomes) are derived under alternative (private

and state-owned) port ownership structures. In Section 4, equilibrium welfare outcomes obtained under alternative port ownership structures are compared and discussed. In Section 5, the endogenous choice by governments on the ownership structure of their ports is analysed. Finally, Section 6 concludes while technical details and proofs are relegated to the final Appendix.

## 2 Related literature

This work relates to the growing literature which analyses the impact of port agents' strategic decisions with respect to the choice of ownership of port facilities.<sup>6</sup> In particular, it is closely related to the work by Matsushima and Takauchi (2014), which is extended here by introducing unionised dockworkers into the analysis, who show that the fact that port usage fees are greater either in public ports or in private ports depends on shipping (or transport) charges: public (resp. private) owned ports set higher port usage fees when shipping costs are high (low). Moreover, several ownership structures can arise in equilibrium based on per unit transport cost: when transport cost is sufficiently low, two outcomes can appear in equilibrium, in which either both or none of the ports are privatised; when transport cost is moderate, both ports are privatised; whilst, when transport cost is high enough, none of the ports are privatised.<sup>7</sup> However, whilst Matsushima and Takauchi (2014) do not consider any port operation cost, introducing port labour cost and, in particular, the role of unions

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<sup>6</sup>For two recent surveys on the industrial organization and game theoretical literature applied to port economics, see Hidalgo-Gallego et al., 2017 and Pujats et al., 2020.

<sup>7</sup>Lee et al. (2017) and Choi and Lim (2018) adopt similar models of Matsushima and Takauchi (2014). Specifically, Lee et al. (2017) incorporate port competition into a third-market model consisting of two exporting firms and one importing country in order to investigate the endogenous choice of port ownership structures when firms compete in the final good market either in prices or in quantities. Choi and Lim (2018) consider an import-competing trade model, where two firms (a home firm and a foreign firm) compete in the same (home) market, to analyse and compare equilibrium outcomes under trade tariff, in which the importing country imposes a specific import tariff, and free trade, as well as to assess the endogenous choices of port ownership structure under alternative trade tariff regimes.

in determining dockworkers' wages allows for a better qualification of their findings. This is because the interplay between union wage setting and the determination of port usage fees affects the final results in a significant way.

Xiao et al. (2012) and Czerny et al. (2014) also study the effects of alternative port ownership structures on port charges and economic outcomes. They both find that privately owned ports set higher port charges than state-owned ones. Moreover, whilst Xiao et al. (2012) do not consider the decision whether to privatise ports and assume the port ownership structure as exogenously given,<sup>8</sup> Czerny et al. (2014) also investigate the endogenous choice by governments on port ownership structures. In particular, in a Hotelling spatial competition model, in which two ports have a monopoly market at home and compete in a third country market for transshipment traffic, they show that strategic complementarity in pricing decisions occurs when ports are privately operated, which may increase the incentives for governments to privatise their ports. However, other than referring to a different framework (in which services of the two ports are substitutes instead of complementary), Czerny et al. (2014), as well as Xiao et al. (2012), do not consider port unions in determining dockworkers' wages, which is instead the main focus of this work. Indeed, to the best of the author's knowledge, the present paper is the first to investigate, in a strategic (game-theoretical) framework, the role and the effect of port unions on port decisions concerning usage charges, as well as on those by governments in relation to port ownership structure.

This paper also refers to the literature that, starting with Brander and Spencer (1988), studies international trade models where wage outcomes are influenced by the presence of trade unions (see, e.g., Mezzetti and Dinopoulos, 1991; Driffill and van der Ploeg, 1993, 1995; Santoni, 1996; Naylor, 1998, 1999; Zhao, 2001). This literature focuses on unionised oligopolies, where unions bargain wages *vis-à-vis* firms, which compete in (international) final product markets. Instead, this paper investigates how the presence of unions affects

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<sup>8</sup>Xiao et al. (2012) compare not only a totally publicly owned port against a completely private structure, but they also include a scenario with partially privatized ports. Furthermore, they study capacity investments by ports under alternative ownership structures.



dockworkers' wages and, in turn, prices (charges) set by ports, which represent the infrastructure that is needed to make international trade possible when firms are located in different countries. Thus, it complements the literature on international trade involving unionised oligopolies.

Finally, since a scenario with a public port in a country and a private port in the other country will be also considered to investigate the endogenous choice by governments on port ownership structure, this study is also related to the literature on mixed oligopolies where a welfare-maximising public firm competes in the market against a profit-maximising private firm (for a survey, see De Fraja and Delbono, 1989). In this literature, extensions of the basic models have been studied, which consider the interaction between governments and competition in international market with two countries (Pal and White, 1998; Bárcena-Ruiz and Garzón, 2005; Dadpay and Heywood, 2006; Han and Ogawa, 2008) and the role of unions in determining workers' wages (De Fraja, 1993; Ishida and Matsushima, 2009). Again, while these models focus on the decisions by firms that compete in the product markets and point out how they are affected by the presence of unions in setting wages, this paper proposes to investigate the effects of unionisation on decisions taken by ports, in a context in which the latter provide complementary (transportation) services to firms, as well as on those by governments in determining port ownership structure, which have not been yet considered by the received literature.<sup>9</sup>

### 3 Model

Consider a two-country setting *à la* Brander and Krugman (1983) where two firms (one in each country) provide their products to two identical countries, thus competing oligopolistically in both countries. Each country has a port and when a firm exports, it must use the two ports. Products are homogeneous and the inverse demand function for each firm is

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<sup>9</sup>Xu and Lee (2021) investigate the effects of port integration in a mixed oligopoly framework where a public port competes against private ports under price competition.

given by:

$$p_i = a - (q_{ii} + q_{ji}) \quad (1)$$

where  $p_i$  denotes the price in country  $i$  and  $q_{ji}$  is the quantity supplied in market (country)  $i$  by the firm located in country  $j$ , with  $i, j = H(home), F(foreign), i \neq j$ . As countries are assumed to be identical, the market size parameter  $a$  is set equal to one, as its level is inconsequential in a qualitative sense.

To export firms incur a per unit shipping fee for competitive shippers, indicated by  $\tau \in (0, \frac{1}{4})$ , as well as a unit fee for usage of each port; in particular, the usage fee of the port in country  $i$  is indicated by  $f_i$ .<sup>10</sup> No cost is incurred by firms other than those associated with transportation. Hence, the profit of firm  $i$  is given by:

$$\Pi_i = \pi_{ii} + \pi_{ij} = p_i q_{ii} + [p_j - (\tau + f_i + f_j)] q_{ij}. \quad (2)$$

In order to carry out their services, ports employ dockworkers (e.g., workers who load and unload cargo) and each port adopts a constant-returns-to-scale technology, where one unit of labour is turned into one unit of service, which corresponds to a unit of goods handled by the port. Moreover, dockworkers are members of labour unions, which set workers' wages to maximise the following objective function:

$$V_i = (w_i - \bar{w})^\theta L_i^{1-\theta} \quad (3)$$

where  $w_i$  is the wage set by the union of port (country)  $i$ ,  $\bar{w}$  is the reservation wage of dockworkers,  $L_i = (q_{ij} + q_{ji})$  is the total amount of goods handled by the port, which equals

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<sup>10</sup>The upper bound for  $\tau$  ensures that ports, whatever their ownership structures (and structural parameter values), are active since, in equilibrium, each firm exports a positive quantity. Relative to the port usage fee  $f_i$ , notice that ports cannot price discriminate between domestic and foreign firms. Indeed, as pointed out by Czerny et al. (2014, p. 213) and Matsushima and Takauchi (2014, p. 384), this is in line with Article 5 of the General Agreement on Tariffs and Trade (GATT) 1994, which requires non-discriminatory treatment between agents in the home and foreign countries.

its level of employment, and  $\theta \in (0, 1)$  is the relative weight placed by unions on wages with respect to employment. In particular, for  $\theta >$  (resp.  $<$ ) 0.5 unions have relatively more wage-oriented (employment-oriented) preferences, while  $\theta = 0.5$  refers to the special case of total wage bill-maximising unions.<sup>11</sup> Without loss of generality,  $\bar{w}$  is set equal to zero to simplify the analysis.

Ports can be privatised or state-owned and, accordingly, their objective function depends on their ownership structure: they maximise profits  $R_i$ , in the case of private ownership, or domestic welfare  $W_i$ , in the case of public ownership. Specifically, their objective functions are given respectively by:

$$R_i = (f_i - w_i)L_i \quad (4)$$

$$W_i = \Pi_i + R_i + CS_i + WB_i \quad (5)$$

where  $CS_i = (q_{ii}^2 + q_{ji}^2 + 2q_{ii}q_{ji})/2$  represents country  $i$ 's consumer surplus and  $WB_i = w_iL_i$  is the total wage bill paid by the port of country  $i$  to its workers.<sup>12</sup>

The timing of the game is as follows. At the first stage, governments of each country choose the ownership structure of their ports. At the second stage, in each port, unions

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<sup>11</sup>In order to keep the analysis as simple as possible, a *monopoly union* model is adopted for wage determination, in which unions can unilaterally set dockworkers' wages since they hold all the bargaining power *vis-à-vis* ports. This framework is standard and largely adopted in the labour economics literature (e.g., Oswald, 1985; Pencavel, 1985; Booth, 1994). Notice, however, that, with some caveats,  $\theta$  could be also interpreted as the relative bargaining power of the union in a bargaining model where wages, instead of being monopolistically set by the union, are bargained between the union and the port. Indeed, as pointed out, e.g., by Lommerud and Straume (2012, p. 184), if we refer to the Nash bargaining solution and denote the relative bargaining power of union  $i$  by  $\beta$ , it is easy to show that  $\theta$  and  $\beta$  enter the Nash (generalised) product in a mathematically similar way, hence producing the same effects on the bargained wage.

<sup>12</sup>Following other studies in the literature (e.g., Brander and Spencer, 1988; Mezzetti and Dinopoulos, 1991; Zhao, 2001), domestic welfare includes the total wage bill rather than union utility. This can be explained by the fact that unions' members are also final consumers. Alternatively, since in our case the wage bill also corresponds to the union's rent, it can be considered as a part of the producer surplus (Bughin and Vannini, 1995).

set wages for their workers. At the third stage, port owners set usage fees. At the final stage, firms choose their quantities in the two markets.<sup>13</sup> At each stage, the agents involved take their decisions simultaneously and, as usual, this game is solved through backward induction. The rest of this section is devoted to the analysis of stages 2–4, whilst the first stage, concerning the choice of port ownership structure, is studied in Section 5.

### 3.1 Market game

At the final stage (market game), each firm maximises Eq. (2) taking port usage fees  $f_i$  and  $f_j$  as given. Using first-order conditions and taking firm symmetry into account, this leads to the following equilibrium outputs at the final stage by the firm located in country  $i$ :

$$q_{ii}(f_i, f_j) = \frac{1 + \tau + f_i + f_j}{3}; \quad q_{ij}(f_i, f_j) = \frac{1 - 2(\tau + f_i + f_j)}{3}. \quad (6)$$

Higher usage fees set by ports discourage firms from selling abroad and make it relatively more convenient to sell their output at home. Moreover, each firm “dumps” the product in the other country by “subsidising” the transportation cost (e.g., Shy, 1995, par. 6.6).

### 3.2 Port usage fees

At the third stage, ports fix their usage fees. This choice is analysed in Matsushima and Takauchi (2014) without considering the presence of dockworkers and their unions, whose role is instead incorporated and investigated in what follows, where a distinction is made between the cases in which ports are privately owned and state-owned respectively.

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<sup>13</sup>The choice of considering union wage setting before port fee setting can be rationalised by the fact that typically wage contracts have a longer duration than contracts that regulate port charges which can be revised much more frequently. In addition, as explained below, a wage increase (negatively) affects port employment only via a port fees increase. Hence, if port fees were set before wages, unions would always have an incentive to raise wages infinitely.

### 3.2.1 Private ports

When both ports are private, they set usage fees to maximise Eq. (4) with respect to  $f_i$ , taking (6) into account. From the first-order condition we get:

$$f_i(f_j) = \frac{1 - 2(\tau + f_j - w_i)}{4} \quad (7)$$

and, exploiting symmetry, the following subgame equilibrium usage fees at the third stage as a function of wages can be obtained:

$$f_i(w_i, w_j) = \frac{1 - 2(\tau - 2w_i + w_j)}{6}. \quad (8)$$

As expected, port fees are strategic substitutes because, as specified by Matsushima and Takauchi (2014, p. 386), “[a] port must lower its port fee given that another port sets a higher fee which reduces international transactions”. Moreover, the usage fee set by port  $i$  is positively related to wages set for its workers by union  $i$ , whilst it negatively depends on  $w_j$  because usage fees are strategic substitutes.

### 3.2.2 Public ports

When both ports are state-owned, at the third stage, taking (6) into account, ports set usage fees to maximise Eq. (5) subject to the following non-negative profit constraint:

$$R_i = (f_i - w_i)L_i \geq 0. \quad (9)$$

Inequality (9) means that there is a budget constraint for the public port, which is not allowed to yield negative profits. Indeed, the total wage bill cancels out in domestic welfare, hence, without a non-negative profit constraint, the optimal usage fee set by the public port does not depend on wages and, as a result, the union can unlimitedly raise its wage.<sup>14</sup>

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<sup>14</sup>This is a well-known issue in the mixed duopoly literature. Ishida and Matsushima (2009) also consider a non-negative profit constraint for the public firm and point out that “[s]ince no firms, including public entities, possess an unlimited amount of resources, it is natural to assume that the public firm faces a

Besides, since we consider a situation in which each port is active, i.e.  $L_i = (q_{ij} + q_{ji}) > 0$ , the budget constraint (9) can also more simply be rewritten as  $(f_i - w_i) \geq 0$ .

When the port budget constraint is not binding, ports choose their fees to maximise domestic welfare, which leads to the following best-reply function in usage fees space:

$$f_i(f_j) = \frac{2 - \tau - f_j}{13} \quad (10)$$

which, in a symmetric subgame equilibrium, leads to  $f_i = \frac{2-\tau}{14}$ .<sup>15</sup>

Instead, when the budget constraint is binding, each port sets a usage fee equal to the wage fixed by the union at the previous stage. Accordingly, the subgame equilibrium usage fees chosen by port  $i$  at this stage can be generally defined as follows:

$$f_i(w_i) = \begin{cases} \frac{2-\tau}{14} & \text{if } \frac{2-\tau}{14} \geq w_i \\ w_i & \text{otherwise.} \end{cases} \quad (11)$$

### 3.3 Wages

At the second stage, dockworkers' wages are determined by port unions, which maximise their utility functions. By differentiating (3) with respect to  $w_i$ , we have that:

$$\frac{dV_i}{dw_i} = \underbrace{\frac{\partial V_i}{\partial w_i}}_{(+)} + \underbrace{\frac{\partial V_i}{\partial L_i} \frac{\partial L_i}{\partial f_i} \frac{\partial f_i}{\partial w_i}}_{(-)} + \underbrace{\frac{\partial V_i}{\partial L_i} \frac{\partial L_i}{\partial f_j} \frac{\partial f_j}{\partial f_i} \frac{\partial f_i}{\partial w_i}}_{(+)} \quad (12)$$

The first term of the r.h.s. of (12) is the positive direct effect of increasing wages on union utility when employment is kept constant. A wage increase also leads to a negative effect on employment, which reduces union utility. However, this negative effect operates only indirectly via the usage fees set by the port and it is captured by the second term of

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restriction of this kind" (Ishida and Matsushima, 2009, p. 638). To solve the issue of unlimited wages set by unions, De Fraja (1993) assumes instead that the public firm maximizes the weighted sum of consumer surplus, profits and the union utility, where the weight attached to the union utility is exogenously given.

<sup>15</sup>Notice that, as the total wage bill cancels out in (5), this replicates precisely the result by Matsushima and Takauchi (2014).

the r.h.s. of (12): a wage increase drives the port to push the usage fee up, which leads to a decrease in production sold abroad by firms and, as a result, reduces port employment. At the same time, this (negative) effect is mitigated by the fact that port usage fees are strategic substitutes, hence a port reacts to a fee increase by the other port by reducing its own fee (this effect is represented by the third term of the r.h.s. of (12)).

Equilibrium wages and subgame perfect Nash equilibrium (SPNE) outcomes are determined in what follows for private and public ports, respectively.

### 3.3.1 Private ports

With private ports, taking (6) and (8) into account, maximisation of Eq. (3) with respect to wages leads to the following best-reply function of union  $i$ :

$$w_i(w_j) = \theta \left( \frac{1 - 2\tau}{2} \right) - \theta w_j. \quad (13)$$

Wages are strategic substitutes. This is because when union  $i$  increases wages, this leads to an increase of the usage fee fixed by its port, which in turn discourages the export of goods, thus reducing employment in each port. Since lower employment corresponds to a point along the port labour demand with higher wage elasticity, this drives union  $j$  to reduce its wages.<sup>16</sup> Furthermore, this effect increases with  $\theta$ . Indeed, a more wage-oriented union will set *ceteris paribus* the wage on a part of the labour demand curve where wages are higher relative to employment, hence the increase in labour demand elasticity, due to a reduction of employment, is more sizeable. Thus, the higher the union orientation towards wages, the larger the increase in labour demand elasticity due to a marginal decrease in employment, determining a stronger reaction of union  $j$  in reducing its wages.

Moreover, union wages negatively depend on shipping fee  $\tau$ . Indeed, when shipping fees increase, selling abroad becomes more expensive. This has a negative effect on port employment, which leads unions to reduce wages and, for the same reason pointed out

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<sup>16</sup>From Eq. (3), we can note that the first-order condition for the optimal wage set by the union leads to  $\eta_i = \frac{\theta}{1-\theta}$ , where  $\eta_i \equiv -\frac{\partial L_i}{\partial w_i} \cdot \frac{w_i}{L_i}$  is the wage elasticity of the port labour demand.

above, this effect increases with  $\theta$ .

By solving the system of best-reply functions given by (13) and the corresponding equation for union  $j$ , we get SPNE wages (the superscript  $PP$  refers to the case in which both ports are private):

$$w_i^{PP} = w_j^{PP} = \frac{\theta(1-2\tau)}{2(1+\theta)}. \quad (14)$$

Then, by substituting back, we obtain SPNE outcomes for usage fees and output:

$$\begin{aligned} f_i^{PP} &= f_j^{PP} = \frac{(1+2\theta)(1-2\tau)}{6(1+\theta)} \\ q_{ii}^{PP} &= q_{jj}^{PP} = \frac{4+5\theta+(1-\theta)\tau}{9(1+\theta)} \\ q_{ij}^{PP} &= q_{ji}^{PP} = \frac{(1-\theta)(1-2\tau)}{9(1+\theta)} \end{aligned}$$

which also lead to the corresponding SPNE profits and other welfare outcomes of this case, all reported, for sake of space, in the final appendix (Section A.1).

### 3.3.2 Public ports

When ports are state-owned, determining SPNE wages is more elaborated. This is because unions consider at this stage that if they choose a wage greater than  $\frac{2-\tau}{14}$ , ports will set usage fees equal to that wage at a later stage. Otherwise, ports will set usage fees equal to  $\frac{2-\tau}{14}$ . However, in this latter case, since usage fees do not depend on wages, increasing wages has no negative effect on employment. As a result, as long as the budget constraint of the public port is not binding, the union will increase wages up to  $\frac{2-\tau}{14}$ .

Let us consider, instead, the case in which the budget constraint is binding. Hence, in determining wages, unions consider that at the following stage  $f_i = w_i$  and union utility maximisation with respect to wages leads to the same union best-reply functions as for private ports (Eq. (13)), hence (by solving the system of best-reply functions) to the same equilibrium wage  $\frac{\theta(1-2\tau)}{2(1+\theta)}$  (see Section A.2 of the final appendix for more detail).



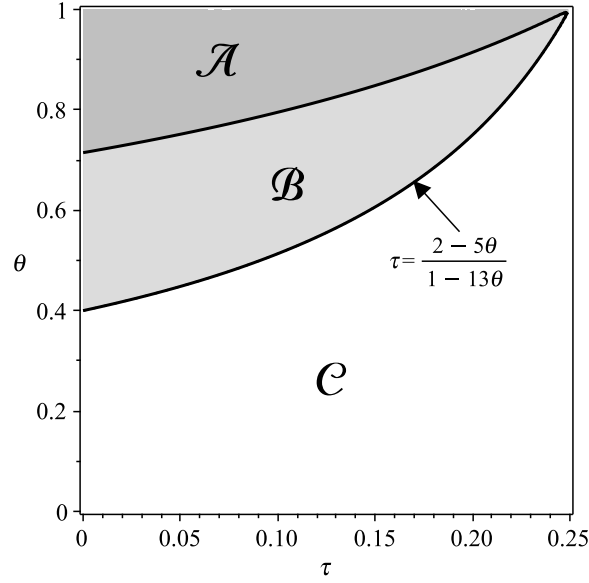


Figure 1: Parameter space partition (Lemma 1)

**Note:** binding port budget constraint: (light) grey; non-binding port budget constraint: white

The following lemma defines, for any combination of parameters  $\tau$  and  $\theta$ , the SPNE wage chosen by unions of state-owned ports at the second stage.

**LEMMA 1.** *Consider the three portions of the parameter space of Figure 1, where:*

- $(\tau, \theta) \in \mathcal{A} : \left\{ \frac{\theta(1-2\tau)}{2(1+\theta)} > \frac{2-\tau}{14} \right\} \wedge \left\{ V_i|_{w_i=f_i=\frac{\theta(1-2\tau)}{2(1+\theta)}} > V_i|_{w_i=f_i=\frac{2-\tau}{14}} \right\}$
- $(\tau, \theta) \in \mathcal{B} : \left\{ \frac{\theta(1-2\tau)}{2(1+\theta)} > \frac{2-\tau}{14} \right\} \wedge \left\{ V_i|_{w_i=f_i=\frac{\theta(1-2\tau)}{2(1+\theta)}} < V_i|_{w_i=f_i=\frac{2-\tau}{14}} \right\}$
- $(\tau, \theta) \in \mathcal{C} : \frac{\theta(1-2\tau)}{2(1+\theta)} < \frac{2-\tau}{14}.$

*Then SPNE wages are as follows (the superscript NN refers to the case in which both ports are state-owned):*

$$w_i^{NN} = w_j^{NN} = \begin{cases} \frac{\theta(1-2\tau)}{2(1+\theta)} & \text{if } (\tau, \theta) \in \mathcal{A} \\ \frac{2-\tau}{14} & \text{if } (\tau, \theta) \in \mathcal{B} \vee \mathcal{C}. \end{cases}$$

*Proof.* See the final Appendix (Section A.3). □

According to Lemma 1, we obtain the following result.

**PROPOSITION 1.** *By comparing wages set by port unions under alternative ownership structures, we have:*

- $w_i^{PP} = w_i^{NN}$ , for any  $(\tau, \theta) \in \mathcal{A}$ ;
- $w_i^{PP} > w_i^{NN}$ , for any  $(\tau, \theta) \in \mathcal{B}$ ;
- $w_i^{PP} < w_i^{NN}$ , for any  $(\tau, \theta) \in \mathcal{C}$ .

*Proof.* Proposition 1 directly derives from Lemma 1 taking into account that, under private ownership, wages set by unions are given by Eq. (14). □

Proposition 1 means that when unions are strongly wage-oriented (or strong in bargaining; see fn 11) and shipping fees are not too high (i.e., for any combination  $(\tau, \theta) \in \mathcal{A}$ ), which corresponds to a situation in which the budget constraint of public ports is binding, dockworkers' wages are the same independently of the port ownership structure. This is an interesting result insofar as the underlying mechanisms that determine wages are very different under alternative ownership structures. Indeed, as analysed in detail in the final appendix (Section A.2), given that equilibrium employment is larger in public ports, the union's marginal benefit of increasing wages (for given employment) is higher under public ownership. At the same time, the union's marginal cost (in terms of lower employment) of increasing wages is also higher in public ports than in private ports because, in the former, the sensitivity of usage fees with respect to wages is greater and the “mitigating effect” on employment reduction (captured by the third term of the r.h.s. of Eq. (12)) is absent. In equilibrium, these effects tend to balance one another, which explains why unions choose the same wage independently of ownership structure.

Instead, when unions are sufficiently, but not excessively, wage-oriented and shipping fees are not too high (i.e., for any combination  $(\tau, \theta) \in \mathcal{B}$ ), wages are higher when ports are

privatised. This is because, under private ownership, wages positively depend on  $\theta$ , whilst under public ownership they do not. In addition, under private ownership, the positive effect of  $\theta$  on wages becomes less sizeable as  $\tau$  increases.<sup>17</sup> For the same reasons, when unions are more employment-oriented or shipping fees are sufficiently high (i.e., for any combination  $(\tau, \theta) \in \mathcal{C}$ ), wages are higher when ports are state-owned. In particular, notice that when  $\theta$  tends to zero (i.e., unions are only concerned about employment), the wage becomes null (or equal to the reservation wage which is normalised to zero) in private ports, while it is positive under public ownership.

The above results clarify the important role played by the budget constraint of public ports in inhibiting the union from becoming overly wage-aggressive, which emerges most clearly especially when the union is not excessively wage-oriented. Indeed, when the budget constraint is not binding, the union is able to increase wages without negatively affecting employment. By contrast, once the budget constraint has become binding, higher wages cause a reduction in employment. This means that when the union is sufficiently employment-oriented, the wage level (i.e.,  $\frac{2-\tau}{14}$ ) which makes the budget constraint binding acts as an upper bound to the union's wage claims.

Once SPNE wages are determined, by substituting back, we get the SPNE outcomes for usage fees and output:

$$\begin{aligned} f_i^{NN} = f_j^{NN} &= \begin{cases} \frac{\theta(1-2\tau)}{2(1+\theta)} & \text{if } (\tau, \theta) \in \mathcal{A} \\ \frac{2-\tau}{14} & \text{if } (\tau, \theta) \in \mathcal{B} \vee \mathcal{C} \end{cases} \\ q_{ii}^{NN} = q_{jj}^{NN} &= \begin{cases} \frac{1+2\theta+(1-\theta)\tau}{3(1+\theta)} & \text{if } (\tau, \theta) \in \mathcal{A} \\ \frac{3+2\tau}{7} & \text{if } (\tau, \theta) \in \mathcal{B} \vee \mathcal{C} \end{cases} \\ q_{ij}^{NN} = q_{ji}^{NN} &= \begin{cases} \frac{(1-\theta)(1-2\tau)}{3(1+\theta)} & \text{if } (\tau, \theta) \in \mathcal{A} \\ \frac{1-4\tau}{7} & \text{if } (\tau, \theta) \in \mathcal{B} \vee \mathcal{C} \end{cases} \end{aligned}$$

which also lead to corresponding SPNE profits and other welfare outcomes of this case, which are all reported in Section A.1 of the final appendix.

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<sup>17</sup>Indeed,  $\frac{\partial w_i^{PP}}{\partial \theta} = \frac{1-(2+\theta)\tau}{2(1+\theta)^2}$ , which is decreasing with respect to  $\tau$ .

## 4 Private and public ownership outcomes: a comparison

In the previous section, the key outcome relative to wages set by port unions has been derived and discussed. Now, a comparison among other (welfare) outcomes under alternative ownership regimes is analysed. First, with reference to port usage fees, the following result applies.

**LEMMA 2.** *Usage fees set by public ports can be higher than those set by private ports only for some combinations  $(\tau, \theta) \in \mathcal{C}$  and, in particular, only if shipping fees are sufficiently high. Moreover, as the union's wage-orientation increases, this possibility becomes increasingly rare because the threshold for  $\tau$ , above which the usage fee is higher under public ownership, increases progressively.*

*Proof.* For parameter value combinations which belong to section  $\mathcal{A}$ , we have that:

$$f_i^{PP} - f_i^{NN} = \frac{(1+2\theta)(1-2\tau)}{6(1+\theta)} - \frac{\theta(1-2\tau)}{2(1+\theta)} = \frac{(1-\theta)(1-2\tau)}{6(1+\theta)} > 0.$$

For parameter value combinations which belong to section  $\mathcal{B}$ , we have that:

$$f_i^{PP} - f_i^{NN} = \frac{(1+2\theta)(1-2\tau)}{6(1+\theta)} - \frac{2-\tau}{14} > 0$$

as, according to Lemma 1, in section  $\mathcal{B}$  we have that  $\frac{2-\tau}{14} < \frac{\theta(1-2\tau)}{2(1+\theta)}$ .

Finally, for parameter value combinations which belong to section  $\mathcal{C}$ , we have that:

$$f_i^{PP} - f_i^{NN} = \frac{(1+2\theta)(1-2\tau)}{6(1+\theta)} - \frac{2-\tau}{14} = \frac{\theta(25\tau-8)+11\tau-1}{42(1+\theta)} \gtrless 0 \Leftrightarrow \tau \gtrless \frac{1+8\theta}{11+25\theta}$$

where  $\frac{1+8\theta}{11+25\theta}$  is increasing with respect to  $\theta$ . □

According to Lemma 2 (see also Figure 2, which provides graphical proof), the presence of unions and, more specifically, as they become more wage-oriented (or powerful in bargaining)

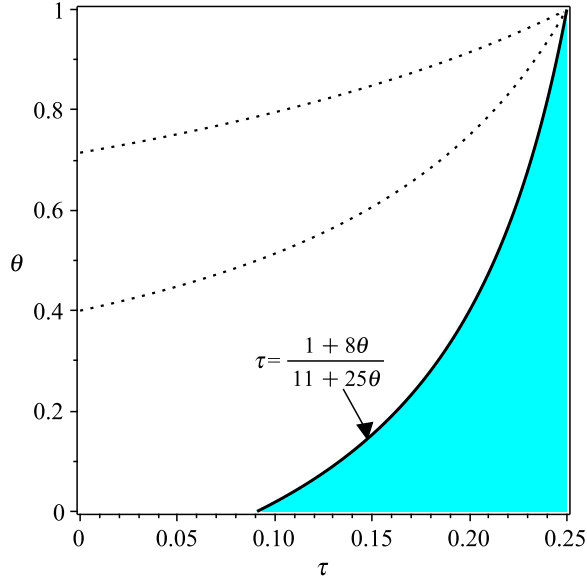


Figure 2: Private vs. public ownership: port usage fees

**Note:**  $f_i^{PP} > f_i^{NN}$ : white;  $f_i^{PP} < f_i^{NN}$ : pale blue

shrinks the area in which port usage fees are higher under public ownership, making this possibility a less likely event as it applies for a smaller set of  $\tau$ 's values.

As the ranking order related to usage fees under alternative port ownership structures basically drives those on welfare outcomes (profits, consumer surplus and domestic welfare), as analysed below, it is worth discussing it in greater detail. To this end, it is useful to start by considering the bottom of Figure 2 relative to the limit case in which  $\theta \rightarrow 0$ , i.e., unions do not place any weight on wages or, alternatively, they have no power in wage bargaining. Indeed, in this case, unions *de facto* do not play any role in affecting final outcomes, hence mimicking the (benchmark) framework and results of Matsushima and Takauchi (2014). Accordingly, the usage fees set by public ports are higher than those set by private ports when the shipping cost is high, i.e.,  $\tau > 1/11 \approx 0.09$ , and *vice versa*.<sup>18</sup>

<sup>18</sup>As analysed in detail in Matsushima and Takauchi (2014), this is because in a given country lower port usage fees benefit consumers but harm the domestic firm and the relevance of the benefit and the cost relates to transport cost. In particular, “the higher the unit transport cost is, the more harmful for a country

Consider now the case with  $\theta > 0$ . In the portions  $\mathcal{B}$  and  $\mathcal{C}$  of Figure 2, as unions are not excessively wage-oriented, the above discussed “wage moderation role” played by the budget constraint of public ports displays its main effects and, under public ownership, usage fees do not depend on wages. More specifically, the usage fee set by a public port is  $\frac{2-\tau}{14}$ , which is not related to  $\theta$ . Instead, usage fees set by a private port increase with wages, which are positively related to  $\theta$ . As a result, as  $\theta$  increases, the set of  $\tau$ ’s values, for which the usage fee set by a public port is higher, shrinks. In particular, in portion  $\mathcal{B}$ , for any value of transport cost,  $\theta$  is too high for a situation in which usage fee is higher in state-owned ports to become a possible event.

Instead, in portion  $\mathcal{A}$  of Figure 2, wages set by unions are the same independently of the port ownership structure, and they are positively related to  $\theta$ . However, the budget constraint of public ports is binding. To maximise welfare, public ports would like to set lower fees but they are constrained to fix them exactly equal to wages. By contrast, private ports can freely maximise their profits, which leads them to fix fees higher than wages. As a result, for any combination between  $\tau$  and  $\theta$  included in portion  $\mathcal{A}$ , port usage fees are higher under private ownership.

**PROPOSITION 2.** *By comparing welfare outcomes under alternative ownership structures, we have that for any  $(\tau, \theta) \in \mathcal{A} \cup \mathcal{B}$  the following ranking orders apply:*

$$\bullet \quad CS_i^{PP} < CS_i^{NN}; WB_i^{PP} < WB_i^{NN}; \Pi_i^{PP} > \Pi_i^{NN}; R_i^{PP} > R_i^{NN}; W_i^{PP} < W_i^{NN}.$$

*Instead, for any  $(\tau, \theta) \in \mathcal{C}$  we have that:*

$$\begin{aligned} \bullet \quad CS_i^{PP} &\geq CS_i^{NN} \text{ when } \tau \geq \frac{1+8\theta}{11+25\theta} \\ \bullet \quad WB_i^{PP} &\geq WB_i^{NN} \text{ when } \tau \geq \frac{81-34\theta+277\theta^2-21\sqrt{33\theta^4+60\theta^3+30\theta^2+12\theta+9}}{8(58\theta^2-31\theta+9)} \\ \bullet \quad \Pi_i^{PP} &\geq \Pi_i^{NN} \text{ when } \tau \leq \frac{1+8\theta}{11+25\theta} \end{aligned}$$

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a decrease in a port usage fee is. In fact, if the unit transport cost is high, the port usage fee set by a nationalized port is higher than usage fee set by a privatized port” (Matsushima and Takauchi, 2014, p. 383).

- $R_i^{PP} > R_i^{NN}$
- $W_i^{PP} \gtrless W_i^{NN}$  when  $\frac{1+8\theta}{11+25\theta} \leq \tau \leq \frac{55+62\theta}{227+241\theta}$ .

*Proof.* See the final Appendix (Section A.4). □

Figure 3 provides graphical proof of Proposition 2, whose results are distinctly different with respect to those in the previous literature, where the role of unions in determining dockworkers' wages and its interplay with the port usage fee setting process were not considered. In particular, in comparison with the results in Matsushima and Takauchi (2014), the event that consumer surplus and domestic welfare are greater under public ownership becomes much more likely (i.e., it holds true for a wider set of shipping costs), especially when port unions are distinctly wage-oriented.

As wages only affect consumer surplus and firm profits indirectly via their impact on port usage fees, the reason why consumer surplus and firm profits ranking orders parallel (inversely or directly, respectively) that of usage fees has already been pointed out by the previous literature.<sup>19</sup> Usage fees negatively affect goods sold abroad and positively goods sold at home, but the negative impact of port usage fees on goods sold abroad, which in equilibrium correspond to those imported by the other country, is larger than the positive impact on goods sold at home. This means that consumer surplus in a country (which is proportional to its overall consumption) negatively depends on port usage fees. Instead, in relation to firm profits, the loss incurred by a firm in the foreign market due to a port usage fee increase is smaller than its gain in the domestic market, hence (equilibrium) firm profits positively depend on usage fees.

The ranking order of port profits is also easy to explain as usage fees are always equal to wages in public ports. Thus, their profits are null and (positive) private port profits are always higher. As far as the total wage bill is concerned, workers generally prefer public ownership of ports. However, as a class, they may prefer private port ownership even if

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<sup>19</sup>For a detailed explanation on the effects of usage fees on firm profits and consumer surplus, see in particular Eqs. (5) and (6) in Matsushima and Takauchi (2014, p. 386) and the discussion provided therein.

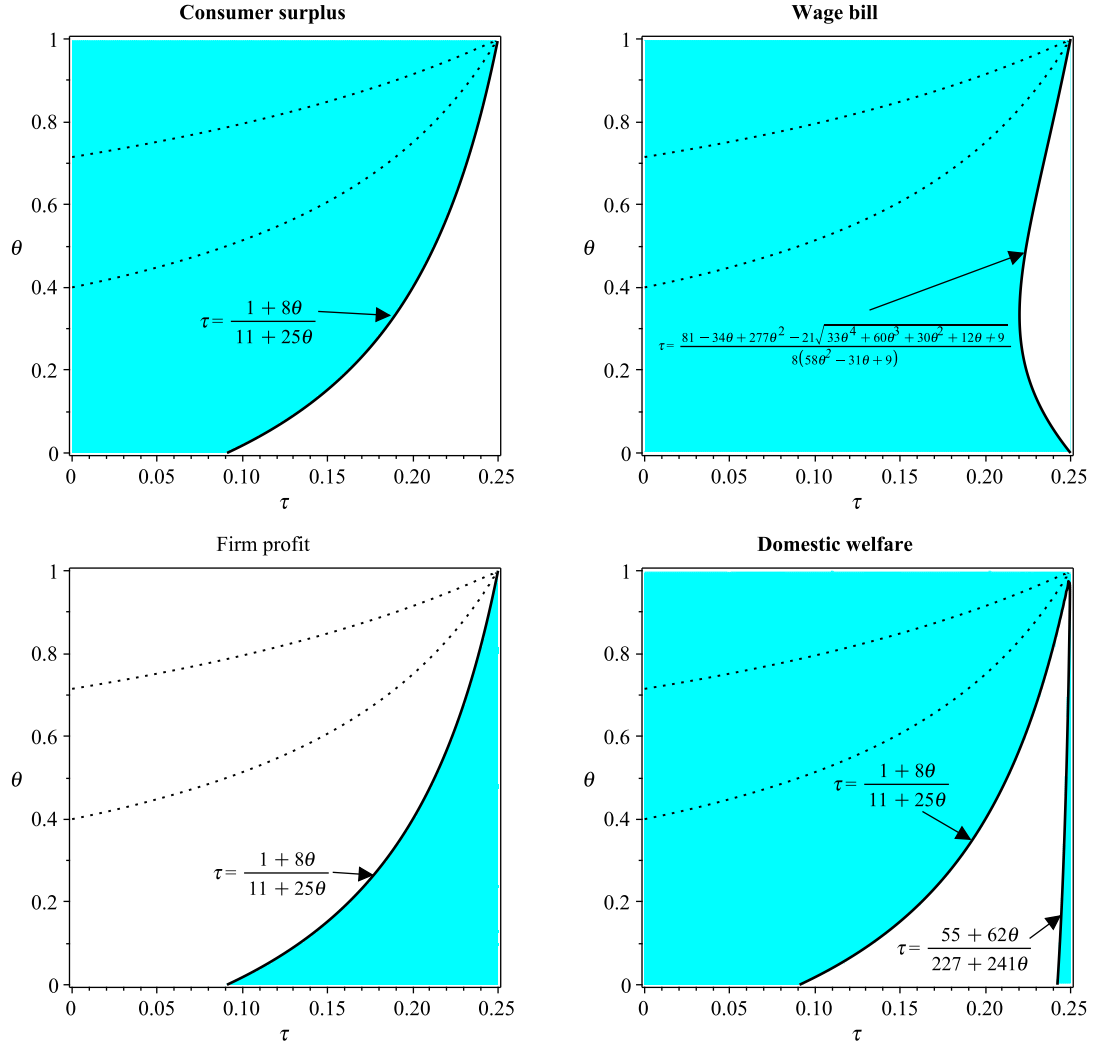


Figure 3: Port ownership structures: welfare comparisons

**Note:**  $\text{outcome}^{PP} > \text{outcome}^{NN}$ : white;  $\text{outcome}^{PP} < \text{outcome}^{NN}$ : pale blue



their wages are lower, as it applies in portion  $\mathcal{C}$ , provided that shipping costs are very high. Indeed, in this case employment in public ports is excessively low as a result of the joint presence of high shipping costs and higher (with respect to private ports) usage fees, which discourages international trade. Finally, the ranking order of domestic welfare, as shown by Figure 3, is driven by that of consumer surplus unless shipping costs are extremely high; indeed, in the latter case, the higher firm profits that we have under public ownership make this structure the one which is able to maximise domestic welfare.<sup>20</sup>

## 5 Endogenous port ownership structure

So far, attention has been placed on deriving equilibrium outcomes with privatised and state-owned ports and comparing relative outcomes. This section will now investigate the endogenous choice of ownership structure or, in other words, the incentive for state-owned ports to become privatised.

In order to deal with this issue, a further initial stage is added to the sequence of the events analysed in Section 3, in which the type of ownership is endogenously selected by each country government to maximise its domestic welfare. In other words, at this stage, governments (simultaneously and independently) decide the type of port ownership (or whether to privatise their ports) and the payoff matrix is represented by Table 1, where  $W_i^{PN}$  is the (subgame perfect) equilibrium domestic welfare obtained by a country whose port is private when the port of the other country is state-owned, while  $W_i^{NP}$  is the (equilibrium) welfare of the latter. In particular, while  $W_i^{PP}$  and  $W_i^{NN}$  (i.e., domestic welfare when both ports are either privatised or nationalised, respectively) are those obtained and compared in Section 3, in order to solve for the equilibrium of the normal game-form of Table 1 (which also allows for the identification of the endogenous port ownership structure), we need to calculate the SPNE values of  $W_i^{PN}$  and  $W_i^{NP}$ .

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<sup>20</sup>Notice that when  $\tau$  and  $\theta$  tend to their upper bounds (i.e.,  $\tau \rightarrow 1/4$  and  $\theta \rightarrow 1$ ), welfare outcomes are the same under alternative ownership regimes.

$i / j$	$P$	$N$
$P$	$W_i^{PP}, W_j^{PP}$	$W_i^{PN}, W_j^{NP}$
$N$	$W_i^{NP}, W_j^{PN}$	$W_i^{NN}, W_j^{NN}$

Table 1: Endogenous ownership structure: normal form

Without loss of generality, let us assume that port  $H$  is state-owned, while port  $F$  is privatised. Again, at the final stage (market game), firms take usage fees and shipping costs as given and compete in quantities, hence the results of Section 3.1 still apply. At the usage fee setting stage, ports simultaneously choose their usage fees in order to maximise their objective functions, with the budget constraint given by Eq. (9) that applies to the public port.

When the budget constraint is not binding, best-reply functions in usage fee space for private and state-owned ports are those given by Eqs. (7) and (10), respectively. Solving the system, we obtain the subgame equilibrium usage fees:

$$f_H(w_F) = \frac{7 - 2\tau - 2w_F}{50}; \quad f_F(w_F) = \frac{9 - 24\tau + 26w_F}{50}. \quad (15)$$

Notice that in this case usage fees of both ports only depend on the wage set by the union in the private port, because the domestic welfare of the other country does not depend on wages. However, whilst  $f_F$  increases with wages set by the union,  $f_H$  negatively depends on wages. Indeed, to prevent a fall in employment, the state-owned port reacts by reducing its usage fee when the other port increases its own as a result of higher wages set by its union.

At the wage setting stage, taking (15) into account, the union of private port sets wages to maximise Eq. (3), which leads to the following SPNE wage:

$$w_F = \frac{\theta(3 - 8\tau)}{8} \quad (16)$$

and, by substituting in (15), SPNE usage fees are:

$$f_H = \frac{28 - 8\tau - \theta(3 - 8\tau)}{200}; \quad f_F = \frac{36 - 96\tau + 13\theta(3 - 8\tau)}{200}. \quad (17)$$

from which the related welfare outcomes can also be obtained (see the final appendix, Section A.1).

In relation to the SPNE wage of the public port, as usage fees and, as a consequence, port employment do not depend on  $w_H$  when the budget constraint does not bind, the union will increase wages up to  $f_H$ , that is, such that:

$$w_H = \frac{28 - 8\tau - \theta(3 - 8\tau)}{200}. \quad (18)$$

Suppose instead that the budget constraint of the state-owned port is binding. At the usage fee setting stage, we have  $f_H = w_H$  while the private port's best-reply function in usage fees is given by (7). Accordingly, at the previous (union wage setting) stage, from the union maximisation problem, we obtain the following equilibrium wages (which exactly replicate those already obtained when ports have the same, private or public, ownership structure; see the final appendix, Section A.2):

$$w_H = w_F = \frac{\theta(1 - 2\tau)}{2(1 + \theta)} \quad (19)$$

and, by substituting back, the corresponding SPNE usage fees are:<sup>21</sup>

$$f_H = \frac{\theta(1 - 2\tau)}{2(1 + \theta)}; \quad f_F = \frac{1 - 2\tau}{4} \quad (20)$$

which also leads to the corresponding welfare outcomes (see the final appendix, Section A.1).

The following lemma specifies which outcomes actually apply in equilibrium for this “asymmetric” case, according to the structural parameters  $\tau$  and  $\theta$ .

**LEMMA 3.** *In an asymmetric port configuration, in which one port is state-owned and the other port is private, the budget constraint of the former is binding whenever:*

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<sup>21</sup>Notice that, for the following results to represent a SPNE, it is not sufficient that the budget constraint is binding because, as already considered in Section 3, there is also the requirement that the union's utility also be higher. However, the proof of Lemma 3 below confirms that this is always true whenever the budget constraint is binding.

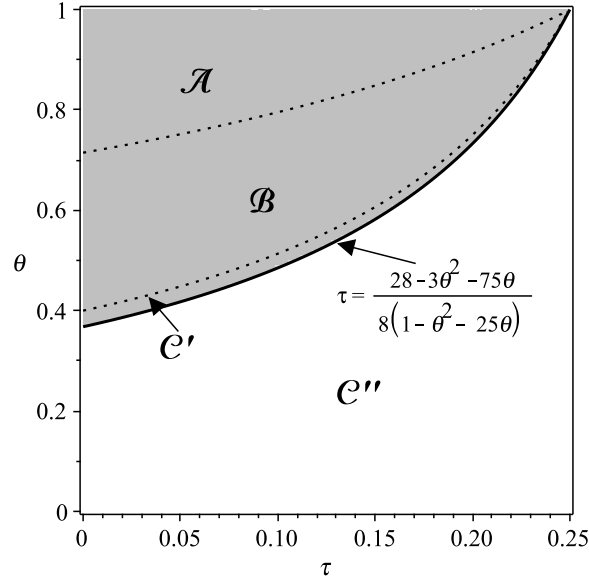


Figure 4: Asymmetric case: public port budget constraint

**Note:** binding port budget constraint: grey; non-binding port budget constraint: white

$$\tau < \frac{28 - 3\theta^2 - 75\theta}{8(1 - \theta^2 - 25\theta)}$$

and, in the SPNE, results (19) and (20) hold true. Otherwise, the budget constraint is not binding and (16), (17) and (18) apply in the SPNE.

*Proof.* See the final Appendix (Section A.5). □

Figure 4 provides a graphical illustration of the set of combinations between  $\tau$  and  $\theta$  for which the budget constraint for the public port is (not) binding in the asymmetric case. In particular, while in portions  $\mathcal{A}$  and  $\mathcal{B}$  the budget constraint is binding, area  $\mathcal{C}$  is now divided into two different sub-areas, labelled as  $\mathcal{C}'$  and  $\mathcal{C}''$ , in which the budget constraint of the public port is, respectively, binding and non-binding.

At this point, considering equilibrium welfare outcomes for any pair of strategies represented in Table 1, the following proposition defines the SPNE decisions by governments at the first stage as regards the ownership structure of their ports.

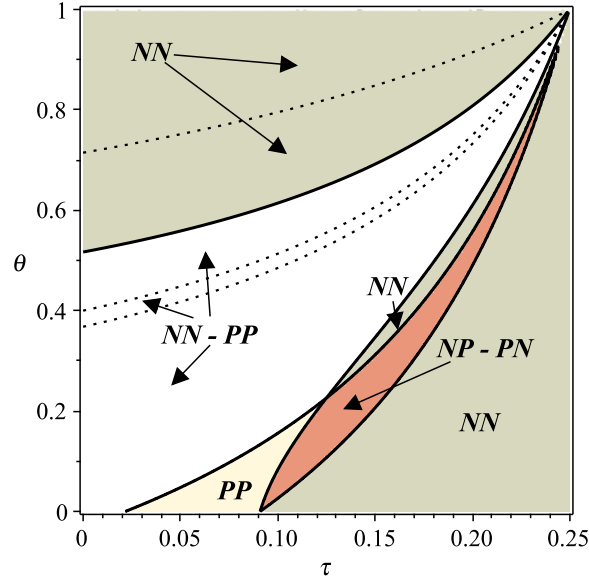


Figure 5: Endogenous port ownership structure

**PROPOSITION 3.** *Consider different partitions of combinations between  $\tau$  and  $\theta$ , as represented in Figure 5. Hence, the following port ownership structures endogenously arise as SPNE of the game between governments:*

- *both ports are state-owned, for any  $(\tau, \theta) \in \langle NN \rangle$ ;*
- *both ports are privatized, for any  $(\tau, \theta) \in \langle PP \rangle$ ;*
- *both ports are either state-owned or privatized, for any  $(\tau, \theta) \in \langle NN - PP \rangle$ ;*
- *one port is state-owned while the other port is privatized, for any  $(\tau, \theta) \in \langle NP - PN \rangle$ .*

*Proof.* See the final Appendix (Section A.6). □

The results, as stated in Proposition 3 and graphically represented in Figure 5 (for further details, see also Figure 6 in the final Appendix A.6), extend those of the received literature by pointing out relevant novelties and confirming the importance of dockworkers and union wage setting in affecting port ownership structure. Indeed, the presence of unionised dockworkers makes a public ownership structure more likely. Moreover, and interestingly, the presence of

dockworkers' unions also makes an asymmetric ownership configuration (with a state-owned port and a private port) a possible event.

More specifically, state-owned ports appear in equilibrium especially when port unions are strongly oriented towards wages (or with strong bargaining power). In addition, even when unions are not wage-oriented, public ownership applies in equilibrium provided that shipping costs are sufficiently high. However, in the latter case, privatisation would be generally (i.e., unless  $\tau$  is very high) preferable in terms of domestic welfare (see Figure 3), hence public ownership causes a prisoner's dilemma. Instead, when unions are strongly wage-oriented, public ownership (or nationalisation) is welfare-enhancing with respect to private ownership.<sup>22</sup> This is because, as shown above, port usage fees are always higher with private ports, hence consumer surplus is penalised more when unions are strongly wage-oriented.

Privatisation of both ports, instead, emerges as a unique (subgame perfect Nash) equilibrium in a significantly rarer situation, that is, when unions are employment-oriented (low  $\theta$ ) and shipping costs are low, but not too low. Furthermore, when it holds true, a prisoner's dilemma situation always arises, since welfare would increase if both ports were nationalised. Indeed, as pointed out by the previous literature (Mantin, 2012; Matsumura and Matsushima, 2012; Matsushima and Takauchi, 2014), in such case, port privatisation causes a rent shift from the foreign country to the domestic country, although expanding the total trade volume through port nationalisation is beneficial for both countries.

Finally, it is worth noting that when an asymmetric configuration, with a private port and a state-owned port, endogenously arises, both countries are better off (in terms of domestic welfare) with respect to the case in which both ports are private. However, when both ports are state-owned, the country with the private port is better off whilst the country with the public port is worse off.<sup>23</sup> To understand this interesting finding, consider that, in

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<sup>22</sup>In Matsushima and Takauchi (2014), public ownership, when arises in equilibrium, is welfare-superior (with respect to private ownership) only in a very specific case, in which shipping costs are extremely high, i.e.,  $55/227 \approx 0.242 < \tau < 0.25$ .

<sup>23</sup>Formally, when  $\tau$  and  $\theta$  are such that an asymmetric port configuration endogenously arises, we have  $W_i^{NP} > W_i^{NN} > W_i^{PN} > W_i^{PP}$  (see the final appendix, Section A.1).

the asymmetric case consumer surplus and firm profits are equal in both countries because output decisions by firms depend on the sum of usage fees chosen by each port. Accordingly, the difference in domestic welfare only depends on port profits and, in particular, on port usage fees. In the parameter space where the asymmetric configuration arises, usage fees are positively (resp. negatively) related with  $\theta$  for a private (public) port. By contrast, (in the same parameter space) usage fees do not depend on  $\theta$  if both ports are state-owned. Hence, starting from a situation in which both ports are public, as  $\theta$  increases, the government of a country may have an incentive to privatise its port since this will lead to higher usage fees and port profits. In addition, the negative impact on trade volume will be mitigated by the fact that the other country's (public) port will react by reducing its usage fees. However, once a port has been privatised, the government of the other country has no incentive to privatise its port. This is because, with two private ports, port usage fees would be too high (and trade volume too low) thus reducing domestic welfare.

## 6 Conclusion

In this paper, the role of unionisation in affecting welfare outcomes under public and private port ownership structures has been investigated by considering an international duopoly, where firms need ports to export their products and dockworkers are unionised. It has been shown that dockworkers' wages are generally higher in public ports, unless unions are strongly wage-oriented or shipping costs are high, while usage fees set by public ports can be higher than those set by private ports only if shipping fees are sufficiently high. However, as the union's wage-orientation increases, the possibility that usage fees set by public ports be higher becomes increasingly rare. Relative to welfare analysis, consumer surplus, total wage bill and domestic welfare are generally higher under public ownership, especially when unions are wage-oriented. The opposite holds true for firm profits, whilst privatisation always increases port profits.

Moreover, the endogenous choice by governments of port ownership structure has also

been analysed. All possible configurations can arise in equilibrium, including an asymmetric one with a state-owned port and a private port. However, state-owned ports appear as the most likely equilibrium result, especially when unions are strongly wage-oriented or shipping costs are sufficiently high. Considering the prominent role played by the human factor in the port domain, these results are a better qualification of those obtained by the received literature as they clarify the prominent effects on welfare outcomes and port ownership structure played by port unions in setting dockworkers' wages.

Future research to extend this work can be carried out in different directions. While this paper considers a situation in which port services are complementary, the introduction of competition between international ports where dockworkers are unionised also deserves to be investigated. Moreover, in an attempt to keep the analysis as simple as possible, some simplifying assumptions have been introduced in relation to product markets (country symmetry, homogeneous product and quantity competition), labour institutions (monopoly union and union symmetry) and port ownership structures (complete public *versus* complete private port ownership structures, while neglecting the possibility of partially privatised ports). Extending this work by abandoning these assumptions represents various options for future research.

## Appendix

### A.1 Welfare SPNE outcomes under alternative port ownership structures

#### A.1.1 Both private ports (*PP*)

$$\begin{aligned}\Pi_i^{PP} = \Pi_j^{PP} &= \frac{(5\tau^2 - 14\tau + 26)\theta^2 - (10\tau^2 - 10\tau - 38)\theta + 5\tau^2 + 4\tau + 17}{81(1 + \theta)^2} \\ CS_i^{PP} = CS_j^{PP} &= \frac{[(4 + \tau)\theta - \tau + 5]^2}{162(1 + \theta)^2} \\ R_i^{PP} = R_j^{PP} &= \frac{[(1 - \theta)(1 - 2\tau)]^2}{27(1 + \theta)^2}\end{aligned}$$



$$WB_i^{PP} = WB_j^{PP} = \frac{\theta(1-\theta)(1-2\tau)^2}{9(1+\theta)^2}$$

$$W_i^{PP} = W_j^{PP} = \frac{(-37\tau^2 + 28\tau + 56)\theta^2 + (2\tau^2 - 2\tau + 122)\theta + 35\tau^2 - 26\tau + 65}{162(1+\theta)^2}.$$

### A.1.2 Both state-owned ports ( $NN$ )

Here we should distinguish between equilibrium outcomes which apply in portion  $\mathcal{A}$  of Figure 1 and those applying in portions  $\mathcal{B}$  and  $\mathcal{C}$ .

In particular, for any  $(\tau, \theta) \in \mathcal{A}$ , we have the following SPNE outcomes:

$$\Pi_i^{NN} = \Pi_j^{NN} = \frac{(5\tau^2 - 8\tau + 5)\theta^2 - (10\tau^2 - 10\tau - 2)\theta + 5\tau^2 - 2\tau + 2}{9(1+\theta)^2}$$

$$CS_i^{NN} = CS_j^{NN} = \frac{[(1+\tau)\theta - \tau + 2]^2}{18(1+\theta)^2}$$

$$R_i^{NN} = R_j^{NN} = 0$$

$$WB_i^{NN} = WB_j^{NN} = \frac{\theta(1-\theta)(1-2\tau)^2}{3(1+\theta)^2}$$

$$W_i^{NN} = W_j^{NN} = \frac{(-13\tau^2 + 10\tau + 5)\theta^2 + (2\tau^2 - 2\tau + 14)\theta + 11\tau^2 - 8\tau + 8}{18(1+\theta)^2}.$$

Instead, for any  $(\tau, \theta) \in \mathcal{B} \vee \mathcal{C}$ , we have the following SPNE outcomes:

$$\Pi_i^{NN} = \Pi_j^{NN} = \frac{10 + 20\tau^2 + 4\tau}{49}$$

$$CS_i^{NN} = CS_j^{NN} = \frac{2(2-\tau)^2}{49}$$

$$R_i^{NN} = R_j^{NN} = 0$$

$$WB_i^{NN} = WB_j^{NN} = \frac{2 + 4\tau^2 - 9\tau}{49}$$

$$W_i^{NN} = W_j^{NN} = \frac{20 + 26\tau^2 - 13\tau}{49}.$$

### A.1.3 Asymmetric case: one state-owned port and one privately owned port ( $NP - PN$ )

Here we should distinguish between equilibrium outcomes that apply when the budget constraint of state-owned port is binding, which, according to Lemma 3, applies when  $\tau < \frac{3\theta^2 + 75\theta - 28}{8(\theta^2 + 25\theta - 1)}$ , and those which apply instead when the budget constraint is not binding.

In particular, for any  $(\tau, \theta)$  for which the budget constraint is binding, i.e., any  $(\tau, \theta) \in \mathcal{A} \vee \mathcal{B} \vee \mathcal{C}'$  in Figure 4, we have the following SPNE outcomes:

$$\begin{aligned}
\Pi_i^{PN} = \Pi_j^{NP} &= \frac{(20\tau^2 - 44\tau + 53)\theta^2 - (40\tau^2 - 40\tau - 62)\theta + 20\tau^2 + 4\tau + 29}{144(1 + \theta)^2} \\
CS_i^{PN} = CS_j^{NP} &= \frac{[7 + 5\theta - 2(1 - \theta)\tau]^2}{288(1 + \theta)^2} \\
R_i^{PN} &= \frac{(1 - \theta)^2(1 - 2\tau)^2}{12(1 + \theta)^2}; \quad R_j^{NP} = 0 \\
WB_i^{PN} = WB_j^{NP} &= \frac{\theta(1 - \theta)(1 - 2\tau)^2}{6(1 + \theta)^2} \\
W_i^{PN} &= \frac{(-52\tau^2 + 28\tau + 107)\theta^2 + (-88\tau^2 + 88\tau + 194)\theta + 140\tau^2 - 116\tau + 131}{288(1 + \theta)^2} \\
W_j^{NP} &= \frac{(-148\tau^2 + 124\tau + 83)\theta^2 + (104\tau^2 - 104\tau + 242)\theta + 44\tau^2 - 20\tau + 107}{288(1 + \theta)^2}.
\end{aligned}$$

Instead, for any  $(\tau, \theta)$  for which the budget constraint is not binding, i.e., any  $(\tau, \theta) \in \mathcal{C}''$  in Figure 4, we have the following SPNE outcomes:

$$\begin{aligned}
\Pi_i^{PN} = \Pi_j^{NP} &= \frac{(64\tau^2 - 48\tau + 9)\theta^2 + (12 - 128\tau^2 + 16\tau)\theta + 64\tau^2 + 32\tau + 104}{500} \\
CS_i^{PN} = CS_j^{NP} &= \frac{[28 - 3\theta - 8(1 - \theta)\tau]^2}{5000} \\
R_i^{PN} &= \frac{3(1 - \theta)^2(3 - 8\tau)^2}{625}; \quad R_j^{NP} = 0 \\
WB_i^{PN} &= \frac{\theta(1 - \theta)(3 - 8\tau)^2}{100}; \quad WB_j^{NP} = \frac{(1 - \theta)(3 - 8\tau)[28 - 3\theta - 8(1 - \theta)\tau]}{2500} \\
W_i^{PN} &= \frac{(-192\tau^2 + 144\tau - 27)\theta^2 - (256\tau^2 - 112\tau + 6)\theta + 448\tau^2 - 256\tau + 408}{1000} \\
W_j^{NP} &= \frac{(832\tau^2 - 624\tau + 117)\theta^2 - (1664\tau^2 - 1248\tau + 234)\theta + 832\tau^2 - 624\tau + 1992}{5000}.
\end{aligned}$$

## A.2 Wage determination under alternative ownership structures when the budget constraint is binding in public ports

This section delves into the results obtained in the main text that, independently of the fact that both ports be private, public or one be private and the other public, wages in a private port are the same as those in a public port when the budget constraint is binding.

Let us start with the case in which both ports are private. Then, by considering the expression (12), as well as firms' and ports' reaction functions in exported goods and usage fees (Eqs. (6) and (8)), from the f.o.c. of the union maximisation problem we have that the optimal wage by the union must satisfy:

$$\begin{aligned}
\overbrace{\theta w_i^{\theta-1} L_i^{1-\theta}}^{\partial V_i / \partial w_i} &= - \left[ \overbrace{w_i^\theta (1-\theta) L_i^{-\theta}}^{\partial V_i / \partial L_i} \times \overbrace{\left(-\frac{4}{3}\right)}^{\partial L_i / \partial f_i} \times \overbrace{\left(\frac{2}{3}\right)}^{\partial f_i / \partial w_i} + \overbrace{w_i^\theta (1-\theta) L_i^{-\theta}}^{\partial V_i / \partial L_i} \times \overbrace{\left(-\frac{4}{3}\right)}^{\partial L_i / \partial f_j} \times \overbrace{\left(-\frac{1}{2}\right)}^{\partial f_j / \partial f_i} \times \overbrace{\left(\frac{2}{3}\right)}^{\partial f_i / \partial w_i} \right] \Leftrightarrow \\
&\Leftrightarrow \underbrace{\theta w_i^{\theta-1} L_i^{1-\theta}}_{\text{union marginal benefit of increasing wages}} = \underbrace{\frac{4}{9} [w_i^\theta (1-\theta) L_i^{-\theta}]}_{\text{union marginal cost of increasing wages}} \quad (A1)
\end{aligned}$$

where, in this case,  $L_i = \frac{2}{9}[1 - 2(\tau + w_i + w_j)]$ . Solving with respect to  $w_i$  leads to the best-reply function (13) in the main text and to the corresponding SPNE wage  $\frac{\theta(1-2\tau)}{2(1+\theta)}$ .

Consider instead the case, in which both ports are public and the budget constraint is binding, hence at the wage setting stage unions consider  $f_i = w_i$ . From the f.o.c. of the union maximisation problem we have that the optimal wage by the union must satisfy:

$$\begin{aligned}
\overbrace{\theta w_i^{\theta-1} L_i^{1-\theta}}^{\partial V_i / \partial w_i} &= - \left[ \overbrace{w_i^\theta (1-\theta) L_i^{-\theta}}^{\partial V_i / \partial L_i} \times \overbrace{\left(-\frac{4}{3}\right)}^{\partial L_i / \partial f_i} \times \overbrace{(1)}^{\partial f_i / \partial w_i} + \overbrace{w_i^\theta (1-\theta) L_i^{-\theta}}^{\partial V_i / \partial L_i} \times \overbrace{\left(-\frac{4}{3}\right)}^{\partial L_i / \partial f_j} \times \overbrace{(0)}^{\partial f_j / \partial f_i} \times \overbrace{(1)}^{\partial f_i / \partial w_i} \right] \Leftrightarrow \\
&\Leftrightarrow \underbrace{\theta w_i^{\theta-1} L_i^{1-\theta}}_{\text{union marginal benefit of increasing wages}} = \underbrace{\frac{4}{3} [w_i^\theta (1-\theta) L_i^{-\theta}]}_{\text{union marginal cost of increasing wages}} \quad (A2)
\end{aligned}$$

where now  $L_i = \frac{2}{3}[1 - 2(\tau + w_i + w_j)]$ , which is higher than employment in private ports, i.e.,  $\frac{2}{9}[1 - 2(\tau + w_i + w_j)]$ . Solving with respect to  $w_i$  leads to the best-reply function in wages space and to the corresponding SPNE wage, which equal those obtained in the previous case with private ports.

Indeed, by comparing (A1) against (A2), we can note that, on the one hand, the union marginal benefit of increasing wages when employment is kept constant is higher in public ports because employment is larger under the latter ownership structure. On the other hand, increasing wages has a negative impact on employment which operates via port usage fees, whose marginal effect on union utility is larger under public ownership. The reason is twofold. First, the sensitivity of usage fees with respect to wages, captured by  $\partial f_i / \partial w_i$ , is larger in public ports. Secondly, the “mitigating effect” on the employment decrease (due to the fact that usage fees are strategic substitutes) does not apply in public ports. The fact that those two (positive and negative) effects of a wage increase on union utility counterbalance each other explains why equilibrium wages in both ownership structures are equal.

Finally, the same wage also applies in equilibrium in the asymmetric case, in which one port is private and one port is state-owned. Specifically, considering, as in Section 5, that port  $F$  is private and port  $H$  is state-owned, from each union maximisation problem, we have:

$$\begin{aligned}
\overbrace{\theta w_F^{\theta-1} L_F^{1-\theta}}^{\partial V_F / \partial w_F} &= - \left[ \overbrace{w_F^\theta (1-\theta) L_F^{-\theta}}^{\partial V_F / \partial L_F} \times \overbrace{\left(-\frac{4}{3}\right)}^{\partial L_F / \partial f_F} \times \overbrace{\left(\frac{1}{2}\right)}^{\partial f_F / \partial w_F} + \overbrace{w_i^\theta (1-\theta) L_F^{-\theta}}^{\partial V_F / \partial L_F} \times \overbrace{\left(-\frac{4}{3}\right)}^{\partial L_F / \partial f_H} \times \overbrace{(0)}^{\partial f_H / \partial f_F} \times \overbrace{\left(\frac{1}{2}\right)}^{\partial f_F / \partial w_F} \right] \Leftrightarrow \\
&\Leftrightarrow \underbrace{\theta w_F^{\theta-1} L_F^{1-\theta}}_{\text{union marginal benefit of increasing wages}} = \underbrace{\frac{2}{3} [w_F^\theta (1-\theta) L_F^{-\theta}]}_{\text{union marginal cost of increasing wages}} \quad (A3)
\end{aligned}$$

and

$$\begin{aligned}
\overbrace{\theta w_H^{\theta-1} L_H^{1-\theta}}^{\partial V_H / \partial w_H} &= - \left[ \overbrace{w_H^\theta (1-\theta) L_H^{-\theta}}^{\partial V_H / \partial L_H} \times \overbrace{\left(-\frac{4}{3}\right)}^{\partial L_H / \partial f_H} \times \overbrace{(1)}^{\partial f_H / \partial w_H} + \overbrace{w_H^\theta (1-\theta) L_H^{-\theta}}^{\partial V_H / \partial L_H} \times \overbrace{\left(-\frac{4}{3}\right)}^{\partial L_H / \partial f_F} \times \overbrace{\left(-\frac{1}{2}\right)}^{\partial f_F / \partial f_H} \times \overbrace{(1)}^{\partial f_H / \partial w_H} \right] \Leftrightarrow \\
&\Leftrightarrow \underbrace{\theta w_H^{\theta-1} L_H^{1-\theta}}_{\text{union marginal benefit of increasing wages}} = \underbrace{\frac{2}{3} [w_H^\theta (1-\theta) L_H^{-\theta}]}_{\text{union marginal cost of increasing wages}} \quad (A4)
\end{aligned}$$

where now  $L_F = L_H = \frac{1}{3}[1 - 2(\tau + w_i + w_j)]$ , which is higher than employment when both ports are private, i.e.,  $\frac{2}{9}[1 - 2(\tau + w_i + w_j)]$  but lower than employment when both ports are public, i.e.,  $\frac{2}{3}[1 - 2(\tau + w_i + w_j)]$ . This means that, in the asymmetric case, in each port the union marginal benefit of increasing wages falls in between the corresponding values related to the cases in which both ports have the same ownership structure. However, the union marginal cost of increasing wages (that, in the asymmetric case, is also the same for both unions) also falls in between those of the cases in which ports have the same ownership structure and, solving with respect to  $w_i$  (A3) and (A4), leads exactly to the same best-reply function in wages space, as well as the same SPNE wage of the previous cases, i.e.,  $\frac{\theta(1-2\tau)}{2(1+\theta)}$ .

### A.3 Proof of Lemma 1

The proof of Lemma 1 is as follows. According to the analysis of Section 3, when the budget constraint of the public port is not binding we have  $f_i = w_i = \frac{2-\tau}{14}$ . Instead, when the budget constraint is binding,  $f_i = w_i = \frac{\theta(1-2\tau)}{2(1+\theta)}$ . Also notice that  $\frac{\theta(1-2\tau)}{2(1+\theta)} > \frac{2-\tau}{14} \Leftrightarrow \tau < \frac{2-5\theta}{1-13\theta}$ .<sup>24</sup>

Accordingly, consider first portion  $\mathcal{A}$  in Figure 1, where each combination between  $\tau$  and  $\theta$  is such that  $\frac{\theta(1-2\tau)}{2(1+\theta)} > \frac{2-\tau}{14}$  and  $V_i|_{w_i=f_i=\frac{\theta(1-2\tau)}{2(1+\theta)}} > V_i|_{w_i=f_i=\frac{2-\tau}{14}}$ . Hence, at the wage setting stage, a union considers that if it sets wages to  $\frac{\theta(1-2\tau)}{2(1+\theta)}$ , in the following stage the port budget constraint is binding and, as a result, usage fees are set equal to wages. In fact, the union may also consider setting lower wages if this can lead

<sup>24</sup>Such a threshold for  $\tau$  can also be obtained by solving (in the SPNE) the multiplier  $\lambda$  of the Lagrangian problem of the public port, which consists of maximising  $\mathcal{L} = W_i + \lambda(f_i - w_i)$ .

to higher employment and, in particular, a wage equal to  $\frac{2-\tau}{14}$  (indeed, for any lower wage the union can increase wages up to  $\frac{2-\tau}{14}$  without negatively affecting employment). However, this cannot be an equilibrium since  $V_i|_{w_i=f_i=\frac{2-\tau}{14}} < V_i|_{w_i=f_i=\frac{\theta(1-2\tau)}{2(1+\theta)}}$ . Hence,  $\frac{\theta(1-2\tau)}{2(1+\theta)}$  represents the SPNE wage of this case and the budget constraint will be binding.

Consider now portion  $\mathcal{B}$  in Figure 1. For any combination of  $\tau$  and  $\theta$ , we have that  $\frac{\theta(1-2\tau)}{2(1+\theta)} > \frac{2-\tau}{14}$  and  $V_i|_{w_i=f_i=\frac{\theta(1-2\tau)}{2(1+\theta)}} < V_i|_{w_i=f_i=\frac{2-\tau}{14}}$ .<sup>25</sup> In this case, given the union's preferences for wages with respect to employment, wages equal to  $\frac{\theta(1-2\tau)}{2(1+\theta)}$  are too high (and corresponding employment is too low) to represent an equilibrium choice by the union. Lower wages can relax the port budget constraint and drive the port to set lower fees, hence leading to higher employment. As  $V_i|_{w_i=f_i=\frac{2-\tau}{14}} > V_i|_{w_i=f_i=\frac{\theta(1-2\tau)}{2(1+\theta)}}$ ,  $\frac{2-\tau}{14}$  is the SPNE wage and, as a result, the budget constraint is not binding. Indeed, at that wage, on the one hand, each union has no incentive to increase wages, which would make the port budget constraint binding, because its utility is reduced. On the other hand, reducing wages further would not have any positive effect on employment because usage fees do not depend on wages.

Finally, consider section  $\mathcal{C}$  in Figure 1, where  $\frac{\theta(1-2\tau)}{2(1+\theta)} < \frac{2-\tau}{14}$  applies for any combination of  $\tau$  and  $\theta$ . Here any wage lower than  $\frac{2-\tau}{14}$ , including  $\frac{\theta(1-2\tau)}{2(1+\theta)}$ , cannot be an equilibrium. This is because the port budget constraint would not be binding, hence the port will set a fee equal to  $\frac{2-\tau}{14}$  in the following stage. But, as long as the budget constraint is not binding, the usage fee and, as a result, employment do not depend on wages and unions have an incentive to increase wages up to  $\frac{2-\tau}{14}$ . Accordingly, the latter is the SPNE wage of this case and the budget constraint is not binding.

## A.4 Proof of Proposition 2

### Consumer surplus

Considering SPNE values of consumer surplus under alternative port ownership structures, as reported in Section A.1 of this appendix, we obtain that, for any  $(\tau, \theta) \in \mathcal{A}$  (see Figure 1):

$$CS_i^{PP} - CS_i^{NN} = -\frac{(1-\theta)(1-2\tau)(4\tau\theta - 4\tau + 7\theta + 11)}{162(1+\theta)^2} < 0.$$

Instead, for any  $(\tau, \theta) \in \mathcal{B} \cup \mathcal{C}$ , we have:

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<sup>25</sup>Unfortunately, due to mathematical complexity, no closed-form expression can be found for the upper bound curve which delimits portion  $\mathcal{B}$  in Figure 1, and it can only be identified numerically (graphically). Notice, however, that in the space of parameters with economic meaning, the upper bound curve of portion  $\mathcal{B}$  is exhaustive; all graphical analyses are obtained with MAPLE (details and programs are available from the author upon request).

$$CS_i^{PP} - CS_i^{NN} = -\frac{(11\tau\theta + 25\tau - 64\theta - 71)(25\tau\theta + 11\tau - 8\theta - 1)}{7938(1 + \theta)^2} \gtrless 0 \Leftrightarrow \tau \gtrless \frac{1 + 8\theta}{11 + 25\theta}.$$

## Total wage bill

Considering SPNE values of the total wage bill under alternative port ownership structures, as reported in Section A.1 of this appendix, we obtain that, for any  $(\tau, \theta) \in \mathcal{A}$  (see Figure 1):

$$WB_i^{PP} - WB_i^{NN} = -\frac{2\theta(1 - \theta)(1 - 2\tau)^2}{9(1 + \theta)^2} < 0.$$

Instead, for any  $(\tau, \theta) \in \mathcal{B} \vee \mathcal{C}$ , we have:

$$\begin{aligned} WB_i^{PP} - WB_i^{NN} &= \\ &= -\frac{(232\tau^2 - 277\tau + 67)\theta^2 - (124\tau^2 - 34\tau + 13)\theta + 36\tau^2 - 81\tau + 18}{441(1 + \theta)^2} \gtrless 0 \Leftrightarrow \\ &\Leftrightarrow \tau \gtrless \frac{81 - 34\theta + 277\theta^2 - 21\sqrt{33\theta^4 + 60\theta^3 + 30\theta^2 + 12\theta + 9}}{8(58\theta^2 - 31\theta + 9)}. \end{aligned}$$

## Firm profits

Considering SPNE values of firm profits under alternative port ownership structures, as reported in Section A.1 of this appendix, we obtain that, for any  $(\tau, \theta) \in \mathcal{A}$  (see Figure 1):

$$\Pi_i^{PP} - \Pi_i^{NN} = -\frac{(1 - \theta)(1 - 2\tau)(20\tau\theta - 20\tau - 19\theta + 1)}{81(1 + \theta)^2} > 0.$$

Instead, for any  $(\tau, \theta) \in \mathcal{B} \vee \mathcal{C}$ , we have:

$$\Pi_i^{PP} - \Pi_i^{NN} = -\frac{(55\tau\theta + 125\tau + 58\theta + 23)(25\tau\theta + 11\tau - 8\theta - 1)}{3969(1 + \theta)^2} \gtrless 0 \Leftrightarrow \tau \gtrless \frac{1 + 8\theta}{11 + 25\theta}.$$

## Port profits

With reference to port profits, the proof that they are higher under private port ownership simply derives by noting that, in equilibrium, profits of public ports are zero, since wages are always equal to the usage fee. Instead, as shown in Section A.1 of this appendix, private ports always obtain positive profits.

## Domestic welfare

Considering SPNE values of firm profits under alternative port ownership structures, as reported in Section A.1 of this appendix, we obtain that, for any  $(\tau, \theta) \in \mathcal{A}$  (see Figure 1):

$$W_i^{PP} - W_i^{NN} = \frac{(1-\theta)(1-2\tau)(40\tau\theta + 32\tau - 11\theta - 7)}{162(1+\theta)^2} < 0.$$

Instead, for any  $(\tau, \theta) \in \mathcal{B} \cup \mathcal{C}$ , we have:

$$W_i^{PP} - W_i^{NN} = -\frac{(241\tau\theta + 227\tau - 62\theta - 55)(25\tau\theta + 11\tau - 8\theta - 1)}{7938(1+\theta)^2} \geq 0 \Leftrightarrow \frac{1+8\theta}{11+25\theta} \leq \tau \leq \frac{55+62\theta}{227+241\theta}.$$

## A.5 Proof of Lemma 3

The proof of Lemma 3 is as follows. According to the analysis of Section 5, in an asymmetric configuration (i.e., one port is state-owned and the other one is private), when the budget constraint of the public port is not binding, we have that the usage fee and the wage of the public port are  $f_H = w_H = \frac{28-8\tau-\theta(3-8\tau)}{200}$ . Instead, when the budget constraint is binding, we have that  $f_H = w_H = \frac{\theta(1-2\tau)}{2(1+\theta)}$ . Moreover we have that  $\frac{\theta(1-2\tau)}{2(1+\theta)} > \frac{28-8\tau-\theta(3-8\tau)}{200} \Leftrightarrow \tau < \frac{28-3\theta^2-75\theta}{8(1-\theta^2-25\theta)}$  and, for any  $\theta \in (0, 1)$  and  $\tau < \frac{28-3\theta^2-75\theta}{8(1-\theta^2-25\theta)}$ ,  $V_H|_{w_H=f_H=\frac{\theta(1-2\tau)}{2(1+\theta)}} > V_H|_{w_H=f_H=\frac{28-8\tau-\theta(3-8\tau)}{200}}$ .

Accordingly, consider first the portions  $\mathcal{A}$ ,  $\mathcal{B}$  and  $\mathcal{C}'$  in Figure 4, where  $\tau < \frac{28-3\theta^2-75\theta}{8(1-\theta^2-25\theta)}$ . At the wage setting stage, the union of the public port considers that if it sets wages to  $\frac{\theta(1-2\tau)}{2(1+\theta)}$ , the port budget constraint is binding at the following stage and, as a result, usage fees are set equal to wages. Moreover, since  $V_H|_{w_H=f_H=\frac{\theta(1-2\tau)}{2(1+\theta)}} > V_H|_{w_H=f_H=\frac{28-8\tau-\theta(3-8\tau)}{200}}$ , there is no advantage for the union of the public port in reducing wages to avoid that the port's budget constraint is binding and obtaining an employment increase. Hence,  $\frac{\theta(1-2\tau)}{2(1+\theta)}$  represents the SPNE wage of the public port and the budget constraint is binding. In addition, taking best reply functions in wages and usage fees into account, SPNE wages and usage fees in the private port are those defined by Eqs. (19) and (20), respectively.

Instead, in section  $\mathcal{C}''$  of Figure 4, we have that  $\tau > \frac{28-3\theta^2-75\theta}{8(1-\theta^2-25\theta)}$ , hence  $\frac{\theta(1-2\tau)}{2(1+\theta)} < \frac{28-8\tau-\theta(3-8\tau)}{200}$  for any combination of  $\tau$  and  $\theta$ . Any wage lower than  $\frac{28-8\tau-\theta(3-8\tau)}{200}$ , including  $\frac{\theta(1-2\tau)}{2(1+\theta)}$ , cannot be an equilibrium because the public port budget constraint would not be binding, hence the port will set a fee equal to  $\frac{28-8\tau-\theta(3-8\tau)}{200}$  in the following stage. But, as long as the budget constraint is not binding, usage fees and, as a result, employment do not depend on wages and unions have an incentive to increase wages up to  $\frac{28-8\tau-\theta(3-8\tau)}{200}$ . As a result, the latter is the SPNE wage of this case and the budget constraint is not binding, hence SPNE fees and wages are those defined by Eqs. (17), (16) and (18).

## A.6 Proof of Proposition 3

Let us start by considering portion  $\mathcal{A}$  of Figure 4. Taking SPNE domestic welfare outcomes of Section A.1 of this appendix into account, we have:

$$W_i^{PP} - W_i^{NP} = \frac{(1-\theta)(1-2\tau)(370\tau\theta - 82\tau - 149\theta + 77)}{2592(1+\theta)^2} < 0, \text{ for any } (\tau, \theta) \in \mathcal{A}$$

$$W_i^{NN} - W_i^{PN} = -\frac{(1-\theta)(1-2\tau)(26\tau\theta + 6\tau - 9\theta + 1)}{96(1+\theta)^2} > 0, \text{ for any } (\tau, \theta) \in \mathcal{A}$$

which imply that, in portion  $\mathcal{A}$ ,  $NN$  is the only equilibrium of the normal-form game of Table 1.

In portion  $\mathcal{B}$  of Figure 4, instead, taking SPNE domestic welfare outcomes of Section A.1 into account, we have:

$$W_i^{PP} - W_i^{NP} = \frac{(1-\theta)(1-2\tau)(370\tau\theta - 82\tau - 149\theta + 77)}{2592(1+\theta)^2} \geq 0 \Leftrightarrow \tau \geq \frac{77 - 149\theta}{2(41 - 185\theta)}$$

$$W_i^{NN} - W_i^{PN} =$$

$$\frac{(10036\tau^2 - 5116\tau + 517)\theta^2 + (19288\tau^2 - 11800\tau + 2014)\theta + 628\tau^2 + 1940\tau - 659}{14112(1+\theta)^2} > 0, \text{ for any } (\tau, \theta) \in \mathcal{B}$$

which imply that, for any  $(\tau, \theta) \in \mathcal{B}$ ,  $NN$  is the only equilibrium of the normal-form game of Table 1 if and only if  $\tau < \frac{77-149\theta}{2(41-185\theta)}$ , otherwise  $PP$  and  $NN$  are both equilibria of the normal-form game of Table 1.

Consider now portion  $\mathcal{C}'$  of Figure 4. Again, taking SPNE domestic welfare outcomes of Section A.1 into account, we have:

$$W_i^{PP} - W_i^{NP} = \frac{(1-\theta)(1-2\tau)(370\tau\theta - 82\tau - 149\theta + 77)}{2592(1+\theta)^2} > 0, \text{ for any } (\tau, \theta) \in \mathcal{C}'$$

$$W_i^{NN} - W_i^{PN} =$$

$$\frac{(10036\tau^2 - 5116\tau + 517)\theta^2 + (19288\tau^2 - 11800\tau + 2014)\theta + 628\tau^2 + 1940\tau - 659}{14112(1+\theta)^2} > 0, \text{ for any } (\tau, \theta) \in \mathcal{C}'$$

which imply that, for any  $(\tau, \theta) \in \mathcal{C}'$ , there are two equilibria of the normal-form game of Table 1 represented by  $PP$  and  $NN$ .

Finally, consider portion  $\mathcal{C}''$  of Figure 4. Taking SPNE domestic welfare outcomes of Section A.1 into account, we have:

$$W_i^{PP} - W_i^{NP} = \Delta(\tau, \theta) \geq 0 \Leftrightarrow \tau \leq \Psi(\theta)$$

$$W_i^{NN} - W_i^{PN} = \frac{(56\tau\theta + 44\tau - 21\theta - 4)(168\tau\theta + 92\tau - 63\theta - 2)}{49000} \leq 0 \Leftrightarrow \frac{2 + 63\theta}{4(23 + 42\theta)} \leq \tau \leq \frac{4 + 21\theta}{4(11 + 14\theta)}.$$

where  $\Delta(\tau, \theta) = -\frac{(67392\tau^2 - 50544\tau + 9477)\theta^4 - (42284\tau^2 - 31088\tau + 7079)\theta^2 - (5000\tau^2 - 5000\tau + 1250)\theta - 20108\tau^2 + 14456\tau - 1148}{405000(1+\theta)^2}$  and  $\Psi(\theta) = \frac{12636\theta^3 + 12636\theta^2 + 4864\theta + 3614 - 225\sqrt{455\theta^4 + 936\theta^3 + 651\theta^2 + 314\theta + 144}}{33696\theta^3 + 33696\theta^2 + 12554\theta + 10054}.$



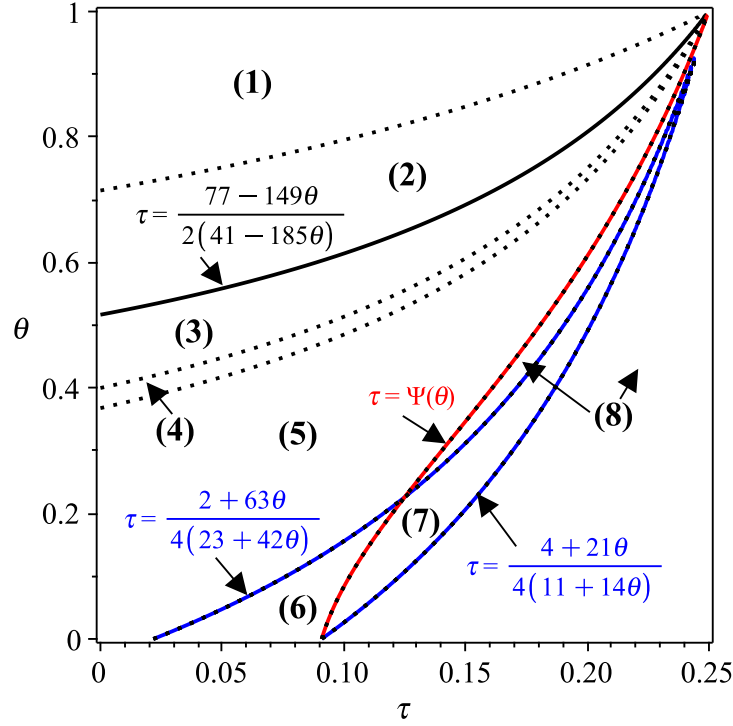


Figure 6: Endogenous ownership structure: parameter space partition

**Note:** in portion (1):  $W_i^{PP} < W_i^{NP}$  and  $W_i^{NN} > W_i^{PN}$ ; in portion (2):  $W_i^{PP} < W_i^{NP}$  and  $W_i^{NN} > W_i^{PN}$ ; in portion (3):  $W_i^{PP} > W_i^{NP}$  and  $W_i^{NN} > W_i^{PN}$ ; in portion (4):  $W_i^{PP} > W_i^{NP}$  and  $W_i^{NN} > W_i^{PN}$ ; in portion (5):  $W_i^{PP} > W_i^{NP}$  and  $W_i^{NN} > W_i^{PN}$ ; in portion (6):  $W_i^{PP} > W_i^{NP}$  and  $W_i^{NN} < W_i^{PN}$ ; in portion (7):  $W_i^{PP} < W_i^{NP}$  and  $W_i^{NN} < W_i^{PN}$ ; in portion (8):  $W_i^{PP} < W_i^{NP}$  and  $W_i^{NN} > W_i^{PN}$ .

This implies that in portion  $\mathcal{C}''$  any possible pair of strategies by ports may arise in equilibrium. In particular: i)  $NN$  is the only equilibrium when  $\langle \tau > \Psi(\theta) \rangle \wedge \langle \frac{2+63\theta}{4(23+42\theta)} > \tau > \frac{4+21\theta}{4(11+14\theta)} \rangle$ ; ii)  $PP$  is the only equilibrium when  $\langle \tau < \Psi(\theta) \rangle \wedge \langle \frac{2+63\theta}{4(23+42\theta)} < \tau < \frac{4+21\theta}{4(11+14\theta)} \rangle$ ; iii)  $PP$  and  $NN$  are both equilibria when  $\langle \tau < \Psi(\theta) \rangle \wedge \langle \frac{2+63\theta}{4(23+42\theta)} > \tau > \frac{4+21\theta}{4(11+14\theta)} \rangle$ ; and iv)  $NP$  and  $PN$  are both equilibria when  $\langle \tau > \Psi(\theta) \rangle \wedge \langle \frac{2+63\theta}{4(23+42\theta)} < \tau < \frac{4+21\theta}{4(11+14\theta)} \rangle$ .

All the above results are graphically summarised in Figure 6.

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