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A MODEL OF PARTIAL REGULATION IN THE MARITIME FERRY INDUSTRY

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A Model of Partial Regulation in the Maritime Ferry Industry

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Abstract

We model a domestic ferry industry providing maritime transportation to a heterogeneous population. This service should guarantee the territorial continuity of countries which have islands. Hinging on several recent EU examples, we assume that the incumbent (eventually) competes as a Stackelberg leader with an entrant, which decides whether and in which segment (residents, non-residents) and season (high, low) to operate. We show that the equilibrium of the market game, in which firms choose prices and frequencies, is socially inefficient. This result suggests that a regulatory intervention is necessary to ensure that sufficient connections are provided at affordable tariffs. We then envisage a regime of *partial regulation* with special tutelage for the residents, in which the dominant shipper is subject to public service obligations, whereas the competitor behaves as a strategic profit-maximizer (whenever it enters). For this scenario, we characterize the optimal complete-information policy.

Keywords: Maritime transport; Price-and-frequency competition; Partial regulation

J.E.L. Classification Numbers: D43, L51, L92, R48

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EXTENDED ABSTRACT

The present work deals with the design of appropriate institutional frameworks for industries providing maritime ferry services. These are services of general interest as they allow for the territorial cohesion and integrity of countries which have islands. In several such European industries, ongoing contracts with statutory monopolies are approaching expiration, some publicly-owned companies are about to go privatized and new shippers (attempt to) enter and operate. Though the specialized literature has devoted close attention to the design of regulatory mechanisms for various transportation sectors, it has not for the ferry service, despite the non-negligible amount of involved resources. We address this issue, which is getting increasingly relevant in Europe, especially after the introduction of the service freedom principle (see the EU Regulation 3577/92).

Hinging on many examples observable in the EU, we stylize a formerly monopolistic industry, where the incumbent (eventually) competes as a Stackelberg leader with an entrant/follower *vis-à-vis* a heterogeneous population of passengers. We show that the exercise of market power makes the market equilibrium hardly satisfactory from a social viewpoint. From this result, we draw a remarkable insight: regulation is needed to ensure the provision of sufficient and affordable connections, in observation of the territorial continuity principle; therefore, it is not advisable that, after the expiration of the contracts and obligations still in force, any institutional constraint is ruled out and the market forces are let operate uncontrolled.

Nowadays, it is difficult to conceive appropriate regulation for the maritime ferry services. The proposal we put forward is meant to address two essential concerns: (1) encourage new operators to enter the industry and make the potential advantages of competition available (efficiency concern); (2) award specific tutelage to the categories of travellers that are particularly penalized by the drawbacks of insularity (distributional concern). The said proposal consists in a *regime of partial regulation*, in which the residents are especially favoured. In the scenario we envisage, the incumbent is subject to social service obligations in terms of tariffs and frequencies, whereas the entrant operates unregulated. Interestingly enough, when the competitor is active, the regulatory purposes can be achieved by compelling the incumbent to milder duties. This result is a striking one: under partial regulation, competition should be viewed as an objective and a valuable instrument at once. The contracts imposing (upper bounds on) prices and (floors on) frequencies, which were typically agreed upon years ago with monopolistic firms and preserve validity still now, do not accommodate for access by rival operators, hence do not suit the actual state of the ferry industry, especially in the high season. An important instruction follows: rather than renewing the existing deals, which neither promote nor exploit the benefits of competition, the regulatory bodies would better set obligations compatibly with the evolution of the sector, along the lines of the partial regulation we characterize. In our view, this is a crucial lesson for future policy.

1 Introduction

Maritime shipping services have long since been liberalized, especially in developed countries. An exception to this can be found in the niche of the market that is mainly constituted by cabotage or short-haul connections. Indeed, in many European countries, the provision of domestic maritime ferry services, connecting islands and mainland, has historically been subject to particular regimes, in order to secure the territorial integrity as well as the cohesion of the islands with the rest of the country. The *territorial continuity principle*, which aims at limiting the drawbacks of insularity by ensuring that islands are served in ways as close as possible to pure mainland connections, has been called upon to justify the introduction of public service obligations and, in many cases, the entrusting of public undertakings with operation. For several years, ferry companies have operated as monopolists, sometimes entitled with exclusive rights to serve specific geographical areas; in countries such as Italy, France and Spain, they used to be and/or are still publicly owned.

In general, long term concession schemes (20 to 25 years) have been adopted, containing a set of specifications laying down the public service framework. These contracts have been generally awarded without public tendering procedures either in consideration of the public nature of the company or because, at the time they were awarded, there was no EU prescription on the matter. In the majority of cases, governments' interests in the sector have translated into burdensome regulatory systems which, depending on the specific approach chosen by the country, concerned frequency, routes, fares, safety, manning rules and so on.

Neither the EU Regulation 3577/92 (European Council [13]), which established that the principle of service freedom would apply to maritime transport as from 1999, nor the Guidelines of state aid to the maritime sector (European Commission [12]) succeeded at significantly modifying the existing regimes. On one side, the 1992 Regulation liberalized the cabotage traffic[1] without effectively encouraging entry of new operators and market competition, where initiated, remains poor. On the other side, the 1997 Guidelines preserved the validity of the concession contracts previously signed. Furthermore, the 2004 Revision of the Guidelines (European Commission [9]) granted a special regime to the traffic with small islands. Indeed, with the Communication on the Interpretation of the Cabotage Regulation (European Commission [10]), the Commission provided for simplified arrangements and ruled that public service contracts for maritime services to small islands should be awarded on the basis of a call for expressions of interest, rather than by the formal invitation to tender. It also extended the contract duration to twelve years (i.e., twice the normal time length). Embodying institutional criteria not evidently inspired by efficiency concerns, this normative framework overall contributes to substantially protect shipping enterprises from competitive pressure and preserve their statutory positions.

While regulatory issues have been extensively studied for most of the transport industries, the domestic ferry service has received very little attention, even in the specialized

[1] Greece was granted a special exemption from full application of the Regulation on cabotage until 2004, in consideration of the relevance of the inter-islands connections.

literature. Despite the similarities with air transportation, the service at stake exhibits a non-negligible number of distinctive features, which deserve specific analysis. Amongst these, the strong seasonality of demand, the social aspects of territorial continuity and the cost structure play a prominent role. The lack of interest might have been justified by the relatively small size of the industry, as compared to other transport sectors. However, this should not lead to the conclusion that the shipping sector is negligible with respect to the economy of the various countries as well as of the whole EU. Indeed, the amount of direct and indirect subsidies involved is surprisingly important: in the UK, where only a few lines off the Scottish coast are subsidized, the associated cost exceeds 50 million euros per year; on the other hand, in Italy, where a more substantial part of the traffics is subsidized, the expense for the public budget is close to 250 million euros (Bergantino [1]). The extent of the issue becomes even more evident if one considers the large number of concerned countries: Italy, Greece, the UK, Ireland, Portugal, Germany, France, Spain, Denmark, Finland, all have subsidized ferry services (European Commission [11]). On a policy ground, the determination of the appropriate regulatory framework is destined to occupy a prominent role in the future regulatory debate, as many of the ongoing long-term contracts are approaching their natural end and some of the publicly owned companies are about to be privatised[2].

In the present paper, by referring to a stylized shipping industry, we attempt to study some of the issues previously highlighted as well as to draw insights which might help from a policy perspective. The European rules establish that, in order to ensure that customers are provided adequate transportation services, public service contracts (PSCs) may be signed and public service obligations (PSOs) imposed in contexts where the spontaneous market forces would not suffice. For the purpose of understanding whether the industry would desirably work even without any institutional constraints, hence whether the latter are actually needed or not, one has to investigate the unregulated market performance. To accomplish this task, we study the equilibrium a (possibly) duopolistic market would achieve, in the absence of any regulatory regimes and/or contractual arrangements. Some kind of control should reasonably be preserved if it turns out that market power is exerted and yields inefficiencies. This necessity is strengthened by the circumstance that the sector at stake provides a service of general interest. Then a crucial question is how to regulate the local maritime industry so that the territorial continuity is guaranteed, without ruling out the efficiency benefits which may become available if entry and competition are sufficiently encouraged, under the principle of service freedom by now in force. In the presence of potential competitors, concluding public service agreements with (or imposing PSOs to) one shipper amounts to implementing a regime of *partial regulation*. By this, we mean a scenario where only the targeted operator is subject to service constraints in the social interests, whereas the other providers behave as pure profit-maximizers. Both whether and how competition takes place in the market crucially depends on the regulatory setup. In situations of this kind, policy designers are in charge with two substantial responsibilities: firstly, access to the industry has to be promoted whenever socially efficient; secondly,

[2] One such example is given by the Gruppo Tirrenia S.p.A., currently belonging to the Italian Ministry of Economics and Finance.

when the unregulated rivals are endowed with market power, the strategic interactions to follow entry have to be indirectly disciplined, so that the advantages of competition are fully exploited. Despite the relevance of the issue for a sector where it proves desirable to input and/or promote the evolution from the monopolistic to the oligopolistic structure, the European legislation does not explicitly fix how to elaborate appropriate regulatory policies. The latter constitute the core motivation of our work, in which we characterize the optimal partial regulation for the maritime ferry industry under complete information.

The paper is organized as follows. The model is presented in Section 2, where we describe consumers' preferences and behaviour as well as shippers' technologies and profit functions. Section 3 is devoted to the analysis of the first-best benchmark. In Section 4, we investigate the two-stage market game, in which enterprises compete in prices and frequencies, and characterize the market equilibrium. Section 5 focuses on the regime of partial regulation and the optimal complete-information policy is determined. Section 6 concludes.

2 The Model

We consider a domestic ferry industry, which provides maritime transportation service to connect localities that are separated by the sea, such as the islands and the continental territory of a country.

In our stylized market, travellers are assumed to be heterogeneous along various directions. Firstly, each passenger is characterized by both an individual taste parameter α and an individual time value τ. Furthermore, the population of passengers can be classified into two types, according to how the choice about the ship to be taken is made. Finally, they can be either residents of the islands (market segment r) or non-residents (market segment n).

Two shippers are (eventually) active on the market, the incumbent enterprise and a potential competitor; they are indexed by $j, k \in \{I, E\}$. The basic period of operation is considered to be the year; within the latter, we identify two main seasons, which we denote by $s = l, h$, where l stays for low season and h for high season.

2.1 The Preferences and Demands

We assume that the maritime ferry services the two shippers provide are characterized by a monetary and a quality dimension. The former is given by the price the specific operator charges, the latter by the number of transfers it performs. Once both tariffs and departure frequency are accounted for, transportation services constitute perfect substitute products. Stemming on this property, we make the hypothesis that passengers may behave in two different ways. Some of them select the shipper whose price-and-frequency policy makes them better off; for simplicity, we say that these are the passengers of type 1. The remaining customers, instead, take the first available ship, whatever the price charged by the operator they travel with; these are the travellers of type 2.

In what follows, we analyse the behaviour of the passengers for each of the types identified above. The residents/non-residents classification, which we neglect at this stage of the study, will become relevant as soon as market competition and regulatory intervention are introduced in the picture.

2.1.1 The Type-1 Passengers

Type-1 passengers patronize the shipper which makes them better off and choose the number of tickets to be purchased solely from this operator. Reasonably enough, these travellers are mainly given by customers exhibiting regular transfer necessities, hence systematically planning their movements between islands and mainland. Several such passengers reside in the islands and need to achieve the continental territory for recurring reasons, such as working. However, we cannot *a priori* identify type-1 travellers as residents.

We suppose that the yearly net utility of the type-1 customer, who is characterized by taste parameter α and time value τ, writes as

$$NU\left(\alpha,\tau;x_j^{s,1}\right)=\sum_{s=l,h}\left[\alpha U\left(x_j^{s,1}\right)-\left(p_j^s+\frac{\tau}{2f_j^s}\right)x_j^{s,1}\right]. \tag{1}$$

In (1), $U(\cdot)$ is the gross utility function, increasing and concave in the argument $x_j^{s,1}$; the latter represents the number of tickets the $(\alpha,\tau)-$individual buys from the selected firm j. The parameter α is assumed to be distributed over the compact interval $[0,+\infty)$, according to the cumulative distribution function $H(\alpha)$ with density $h(\alpha)$; similarly, the time value τ ranges over the interval $[0,+\infty)$, according to the cumulative distribution function $G(\tau)$ with density $g(\tau)$. Furthermore, p_j^s is the tariff charged and f_j^s the number of connections supplied by shipper j in season s. The sum $\left(p_j^s+\tau/2f_j^s\right)$ measures the so-called *generalised cost*, which is given by the monetary price together with the disutility $\tau/2f_j^s$ associated to the departure delay; hence, it is the total unit cost the passenger bears. In particular, the ratio $1/2f_j^s$ is determined under the hypothesis that the ideal departure time is uniformly distributed along the time interval between any two departures[3].

Given prices and frequencies, the optimal demand for travels in season $s=h,l$ is characterized by the condition

$$\alpha U'=p_j^s+\frac{\tau}{2f_j^s}, \tag{2}$$

suggesting that, at optimum, the utility the consumer derives from the last purchased ticket, provided that her individual taste parameter is α, equals the generalised cost. As (2) shows, α has a direct impact on the demand volume; indeed, fixing the generalised cost, the larger α, the smaller the marginal utility U', hence the bigger the optimal number of travels.

Observe that (2) can be used to establish the relation between demand variations, as induced by changes in shipper j's price and frequency, assuming that the pair (p_k^s,f_k^s) remains fixed. Indeed, since (2) holds for any p_j^s, differentiating both sides with respect

[3] See Billette de Villemeur [3] for a similar formulation of the utility function in a context of air transportation.

to p_j^s yields

$$\alpha U'' \frac{\partial x_j^{s,1}}{\partial p_j^s} = 1, \tag{3a}$$

meaning that a unitary increase in price p_j^s induces a unitary increase in the marginal utility of the service for the $\alpha-$passenger, through the variation intervened in her demand. According to (3a), the increment in marginal utility is decreasing in the individual preference for the service; hence, whenever price p_j^s is diminished by one unit, the marginal utility reduces relatively less for the passengers who benefit more from travelling. This suggests that their consumption is less negatively affected by price increases than the others'.

On the other hand, since (2) is true for any f_j^s, $s = h, l$, differentiating with respect to this variable returns

$$\alpha U'' \frac{\partial x_j^{s,1}}{\partial f_j^s} = -\frac{\tau}{\left(f_j^s\right)^2}, \tag{3b}$$

revealing that a unitary increase in frequency induces a reduction equal to $\tau / \left(f_j^s\right)^2$ in the marginal utility of the $\alpha-$customer, through the change in demand. Observe that the higher the frequency initially provided by firm j, the smaller the variation in marginal utility induced by further scheduling. Indeed, when the shipper already offers very frequent transfers, receiving more causes a relatively small increase in the demand for the service; it follows that the associated change in marginal utility is limited as well.

The marginal rate of substitution between price p_j^s and quality f_j^s, $s = h, l$, is given by

$$-\frac{\partial NU\left(x_j^{s,1}\left(\alpha, \tau; \mathbf{p}^s, \mathbf{f}^s\right)\right) / \partial f_j^s}{\partial NU\left(x_j^{s,1}\left(\alpha, \tau; \mathbf{p}^s, \mathbf{f}^s\right)\right) / \partial p_j^s} = \frac{\tau}{2\left(f_j^s\right)^2},$$

where $x_j^{s,1}\left(\alpha, \tau; \mathbf{p}^s, \mathbf{f}^s\right)$ is the optimal demand in season s, given the vectors of prices $\mathbf{p}^s = \begin{pmatrix} p_j^s & p_k^s \end{pmatrix}$ and frequencies $\mathbf{f}^s = \begin{pmatrix} f_j^s & f_k^s \end{pmatrix}$. The marginal rate of substitution reveals the customers' *internal* relative valuation of quality and monetary charge for the transportation service supplied by firm j, keeping the pair (p_k^s, f_k^s) constant. More precisely, it measures, in a marginal sense, how much additional connection frequency f_j^s the traveller would require as a compensation for a unitary increase in price p_j^s, in order to keep the same level of satisfaction. Furthermore, the above expression shows that, in the current framework, the marginal rate of substitution between money and quality can be monotonically ranked; indeed, for any $\left(p_j^s, f_j^s\right)$, travellers' indifference curves always increase in τ in the space of firm j's price and frequency[4]. Therefore, starting from some price level, if an increase occurs (and provided that the rival policy remains fixed), people exhibiting relatively larger disutility from waiting need to be compensated by a relatively smaller increase in frequency, if compared to little-τ people, for preserving the initial degree of satisfaction. Putting things differently, those who dislike waiting more for the subsequent

[4]It is straightforward to check that the partial derivative of the marginal rate of substitution equals $1/2\left(f_j^s\right)^2$, which has constant sign, whatever p_j^s and f_j^s (in particular, it is positive). This is known as the Spence-Mirrlees property.

transfer are ready to pay relatively more for a frequency increment than travellers who are less concerned with time waste. On the other hand, such a rate proves to be invariant in α, so that individuals' indifference curves cannot be ranked according to their taste parameter. This is so because, as previously observed, α affects the quantity of travels passengers demand, hence their consumption volume, rather than their relative valuation of money and quality at the margin.

2.1.2 The Type-2 Passengers

We now turn to the analysis of type-2 passengers' behaviour. The latter perceive the maritime transportation service as a "unique aggregate good", whatever operator provides the transfers. When they need to travel, they are not available to wait for subsequent ships; they rather prefer to take the ship setting sail next, indifferently of the price to be paid for the ticket. Typically, these passengers do not live in the islands and mainly travel for occasional reasons, such as touristic visits. Nevertheless, as we pointed out for type-1 passengers and non-residents, we cannot exclude that, under some circumstances, residents behave as type-2 passengers as well.

Several aspects of the study constitute a generalization of those we highlighted for type-1 customers; therefore, in this Section, we do not need to be as detailed as in the previous one. We rather stress analogies and differences, whenever they arise.

We suppose that the yearly net utility function of the type-2 (α, τ) $-$customer is given by

$$NU\left(\alpha, \tau; x^{s,2}\right) = \sum_{s=l,h} \left[\alpha U\left(x^{s,2}\right) - \left(p^{e} + \frac{\tau}{2f^{s}}\right) x^{s,2}\right], \tag{4}$$

where $x^{s,2} = \sum_{j=I,E} x_j^{s,2}$ expresses the number of tickets she buys from both firm j and k, $U(\cdot)$ is the gross utility function, increasing and concave in either argument $x_j^{s,2}$, $j = I, E$, and $f^s = \sum_{j=I,E} f_j^s$ indicates the total connection frequencies offered by the industry in season s. Furthermore, $p^e = \sum_{j=I,E} f_j^s p_j^s / f^s$ represents the expected price to be paid, the weights of the single tariffs p_j^s, $j = I, E$, being the relative frequencies. Therefore, the sum $(p^e + \tau/2f^s)$ measures the *generalised expected cost*, which is now given by the expected monetary price together with the disutility associated to the departure delay.

Given prices and frequencies, the optimal demand in season $s = h, l$ is characterized by the equality

$$\alpha U' = p^e + \frac{\tau}{2f^s}, \tag{5}$$

hence it is increasing in the taste parameter α and decreasing in the time disutility τ. Similarly to what we did for type-1 passengers, we differentiate (5) with respect to p_j^s and obtain

$$\alpha U'' \frac{\partial x^{s,1}}{\partial p_j^s} = \frac{f_j^s}{f^s}. \tag{6a}$$

(6a) means that, for an individual with taste α, a unitary increase in price p_j^s induces an increase f_j^s/f^s in the marginal utility of the service through the variation intervened in her demand. Therefore, the increment in marginal utility is increasing in the probability f_j^s/f^s that a ship of firm j is the next available one: the higher the probability that the ship to be taken belongs to operator j, the more the passenger reduces her demand for the service as a reaction to the price increase.

Analogously, differentiating with respect f_j^s yields

$$\alpha U'' \frac{\partial x^{s,1}}{\partial f_j^s} = \frac{f_k^s}{f^s}\left(\frac{p_j^s - p_k^s}{f^s}\right) - \frac{\tau}{2\left(f^s\right)^2}. \tag{6b}$$

According to (6b), the variation induced by a unitary increase in frequency in the marginal utility of the individual with taste α is equal to $\left[f_k^s\left(p_j^s - p_k^s\right) - \tau/2\right]/\left(f^s\right)^2$. As compared to (3b), (6b) contains the additional term $f_k^s\left(p_j^s - p_k^s\right)/\left(f^s\right)^2$, revealing that not only the disutility from time waste, but also the spread between prices and the frequency provided by the rival operator contribute to determine the impact of an increase in firm j's quality on the marginal utility of the $(\alpha, \tau)-$agent. In particular, an increment in f_j^s causes a reduction in marginal utility (as demand is augmented) in either of the two following cases:

1. If $p_k^s > p_j^s$ so that $f_k^s\left(p_j^s - p_k^s\right) - \tau/2 < 0$. Since the latter inequality rewrites as $\tau > 2f_k^s\left(p_j^s - p_k^s\right)$ and $\left(p_j^s - p_k^s\right) < 0$, we can conclude that, whenever the price charged by the firm whose frequency grows is lower than the rival price, any type-2 passenger increases her demand for transportation service, following to such a frequency increment, independently of the individual time value[5]. Intuitively, any traveller is better off as the frequency (hence, the probability) of the cheaper shipper becomes larger.

2. If $p_j^s > p_k^s$ and $f_k^s\left(p_j^s - p_k^s\right) < \tau/2$, in which case we still have $\left[f_k^s\left(p_j^s - p_k^s\right) - \tau/2\right] < 0$. Under these circumstances, the inequalities $p_k^s < p_j^s < (p_k^s + \tau/2f_k^s)$ hold, meaning that, though the price charged by firm k is lower than the rival one, it remains smaller than the generalised cost the traveller would bear by patronizing solely firm k. Therefore, as f_j^s increases and so does f_j^s/f^s, i.e. the probability that the first available ship belongs to operator j, the service becomes more attractive, demand is increased and marginal utility reduces. Notice that this scenario realizes for all the values of τ that are larger than $2f_k^s\left(p_j^s - p_k^s\right)$, which is now positive; in other words, the marginal utility of the service decreases, following to a frequency increase by operator j, only for the type-2 passengers exhibiting sufficiently high disutility of waiting.

In either of the above cases, combining (6a) and (6b), we can establish that type-2 passengers' marginal rate of substitution between quality f_j^s and money p_j^s exhibit the same properties as type-1 consumers', that is it is constant in α and increasing in τ[6].

For the analysis to be complete, we also need to investigate whether and under which circumstances the marginal utility of the service might be negative, meaning that the

[5] Recall that τ is (weakly) positive by assumption.

[6] In particular, one finds that the partial derivative of the marginal rate of substition is equal to $1/2f_j^s f^s$, which is a positive quantity.

passenger would reduce her demand for transfers, despite the increase in the quality of firm j's service. For the quantity $\left[f_k^s\left(p_j^s - p_k^s\right) - \tau/2\right]$ to be positive, it should be the case that $\left(p_j^s - p_k^s\right) > \tau/2f_k^s$ or, equivalently, that $p_j^s > (p_k^s + \tau/2f_k^s) > p_k^s$. Then the price of service j would be sufficiently high to exceed the generalised cost (and, *a fortiori*, the monetary price) of the rival service. An increase in the probability of taking ship j would make the service less attractive, hence $x^{s,2}$ would reduce and U' grow. Interestingly, the conditions previously reported would be met for $\tau < 2f_k^s\left(p_j^s - p_k^s\right)$, that is for sufficiently low values of τ. Precisely because these passengers are quite patient, that is they do not significantly suffer from waiting, they would not benefit from a frequency increase, were it to occur for the more expensive firm. Therefore, they would react by simply reducing their demand for the service, if the more expensive ship were to become more likely to depart next. In this case, both price p_j^s and frequency f_j^s would impact passengers' net utility in the same direction; therefore, all else equal, the customers under scrutiny should be compensated for an increase in p_j^s by reducing, rather than increasing, f_j^s. For them, the marginal rate of substitution between quality and money would decrease in τ : the larger the time value, the smaller the frequency reduction that would be needed to overwhelm the tariff increase. As we will see at later stage, this scenario never actually realizes.

2.1.3 Endogenising Passengers' Behaviour

We have previously explained that the services offered by the two operators are perfect substitutes, once prices and frequencies are taken into account. Therefore, if generalised costs, rather than monetary prices, are compared, the opportunity for substitution allows each consumer either to select the provider offering the cheaper service, depending on her own frequency valuation (that is, behaving as type-1 passengers), or to consider services as a unique good (that is, behaving as type-2 passengers). In what follows, we analyse how this choice is made, which amounts to endogenising the types according to passengers' time values.

The $\tau-$passenger is better off by behaving as type 2 (the $(j,k)-$option), rather than patronizing firm j only (the $j-$option), whenever a lower generalised cost is involved. The condition for this to be the case writes as

$$p^e + \frac{\tau}{2f^s} < p_j^s + \frac{\tau}{2f_j^s} \quad \Leftrightarrow \quad \tau > 2f_j^s\left(p_k^s - p_j^s\right). \tag{7a}$$

In the event that $p_k^s > p_j^s$, we can define $\tau_{mg}^{s,2,j} \equiv 2f_j^s\left(p_k^s - p_j^s\right)$ the time value of the marginal customer: people exhibiting larger τ behave as type 2, whereas those with smaller τ are better off by choosing firm j[7]. In the opposite circumstance, that is with $p_k^s < p_j^s$, there does not exist $\tau_{mg}^{s,2,j} > 0$; hence, all passengers prefer to act as type 2, rather than patronizing firm j.

Similarly, the condition for the $\tau-$consumer to prefer the $(j,k)-$option, rather than

[7]This and all the other cutoff types identified in the text are indifferent between the two options they separate.

choosing firm k, is given by

$$p^e + \frac{\tau}{2f^s} < p_k^s + \frac{\tau}{2f_k^s} \quad \Leftrightarrow \quad \tau > 2f_k^s \left(p_j^s - p_k^s\right). \tag{7b}$$

With $p_j^s > p_k^s$, we can identify the cutoff time value $\tau_{mg}^{s,2,k} \equiv 2f_k^s \left(p_j^s - p_k^s\right)$, such that people with higher τ act as type 2, those with lower τ prefer travelling with firm k to being type 1. Conversely, with $p_j^s > p_k^s$, everybody is better off by using a unique aggregate service, rather than choosing always enterprise k. Remarkably, it is impossible that $\tau_{mg}^{s,2,j}$ and $\tau_{mg}^{s,2,k}$ simultaneously exist[8]: whenever passengers split between patronizing firm j, say, and being type 2, nobody prefers firm k to acting as type 2.

The previous results are particularly instructive. Indeed, they allow to refine one of the conclusions deduced from the investigation about type-2 passengers, namely that people whose time value is smaller than the cutoff value should, in principle, reduce their demand for transportation service, as they become more likely to take the more expensive ship. In the light of (7a) and (7b), we can exclude that such a scenario ever realizes, because the low-τ passengers at stake do not behave as type 2.

We finally compare the preference for shipper j to that for shipper k. The $\tau-$consumer is better off with the former if and only if

$$p_j^s + \frac{\tau}{2f_j^s} < p_k^s + \frac{\tau}{2f_k^s}.$$

Supposing, without loss of generality, that $f_j^s > f_k^s$, from the previous inequality we easily obtain

$$\tau > 2f_j^s f_k^s \left(\frac{p_j^s - p_k^s}{f_j^s - f_k^s}\right). \tag{9}$$

In the event that $p_j^s > p_k^s$, the time value which identifies the cutoff point within the support is given by $\tau_{mg}^{s,1} \equiv 2f_j^s f_k^s \left(p_j^s - p_k^s\right) / \left(f_j^s - f_k^s\right)$. Therefore, all customers with $\tau > \tau_{mg}^{s,1}$ prefer enterprise j to k; conversely, people with $\tau < \tau_{mg}^{s,1}$ are better off with shipper k. Notice that, under the previous assumption about frequencies, the condition on prices that is required for the existence of $\tau_{mg}^{s,1}$ is the one under which $\tau_{mg}^{s,2,j}$ does not exist, whereas $\tau_{mg}^{s,2,k}$ does exist. This circumstance allows to identify the ordering structure which characterizes the preferences. To see this, consider that type-1 consumers split between operators because shipper j provides better quality then its rival, but charges higher monetary price. On the other hand, if passengers are asked to choose between waiting for operator j and just taking the next ship setting sail (the $k-$alternative being unavailable), then they prefer the second option. Nevertheless, as soon as the $k-$alternative is compared to the $(j,k)-$option, splitting arises again. One can already guess that travellers finally behave either as type 1 patronizing firm k or as type 2.

In what follows, we illustrate the previous point in further details. More precisely, we describe passengers' behaviour for each possible scenario, namely $f_j^s > f_k^s$ together with

[8] In the extreme event that $p_j^s = p_k^s$, we have $\tau_{mg}^{s,2,k} = \tau_{mg}^{s,2,j} = 0$, that is both cutoff values collapse onto the lower extreme of the support. In this scenario, those customers who suffer no disutility from waiting are indifferent between type-1 and type-2 behaviour, whereas all the others are better off by acting as type 2.

$p_j^s > p_k^s$ and $f_j^s > f_k^s$ together with $p_j^s < p_k^s$[9].

Scenario 1: $f_j^s > f_k^s$ and $p_j^s > p_k^s$. Whenever the operator charging higher price also provides larger frequency, the following outcomes are realized:

- $\exists \tau_{mg}^{s,1} > 0$: Passengers with $\tau > \tau_{mg}^{s,1}$ prefer shipper j to shipper k; those with $\tau < \tau_{mg}^{s,1}$ prefer shipper k to shipper j.
- $\nexists \tau_{mg}^{s,2,j} > 0$: Whatever the time value, passengers prefer behaving as type 2 rather than patronizing operator j.
- $\exists \tau_{mg}^{s,2,k} > 0$: Passengers with $\tau > \tau_{mg}^{s,2,k}$ prefer acting as type 2 to choosing shipper k; those with $\tau < \tau_{mg}^{s,2,k}$, instead, prefer the $k-$option.

In order to relate the first point to the final one, we compare $\tau_{mg}^{s,1}$ to $\tau_{mg}^{s,2,k}$ and check whether any relation can be established between the two cutoff values. Indeed, it turns out that $\tau_{mg}^{s,2,k} < \tau_{mg}^{s,1}$. As a result, passengers' behaviour classifies as follows:

- Firm k is patronized by travellers whose $\tau \in \left[0, \tau_{mg}^{s,2,k}\right)$.
- The $(j,k)-$option prevails for travellers whose $\tau \in \left(\tau_{mg}^{s,2,k}, +\infty\right)$.

As it is evident, $\tau_{mg}^{s,1}$ is irrelevant because travellers whose $\tau \in \left(\tau_{mg}^{s,2,k}, \tau_{mg}^{s,1}\right)$ prefer (j,k) to k and k to j.

Finally, it is straightforward to compute the resulting shippers' aggregate demand functions; we have

$$\begin{aligned} X_k^s &= X_k^{s,1} + \frac{f_k^s}{f^s} X^{s,2} \qquad (10a) \\ &= \int_0^{\tau_{mg}^{s,2,k}} \int_\alpha x_k^{s,1} h(\alpha) g(\tau) \, d\alpha d\tau + \frac{f_k^s}{f^s} \int_{\tau_{mg}^{s,2,k}}^{+\infty} \int_\alpha x^{s,2} h(\alpha) g(\tau) \, d\alpha d\tau \end{aligned}$$

and

$$X_j^s = \frac{f_j^s}{f^s} X^{s,2} = \frac{f_j^s}{f^s} \int_{\tau_{mg}^{s,2,k}}^{+\infty} \int_\alpha x^{s,2} h(\alpha) g(\tau) \, d\alpha d\tau \qquad (10b)$$

for firm k and j respectively.

Scenario 2: $f_j^s > f_k^s$ and $p_j^s < p_k^s$. We now consider the case where the shipper (here, firm j) which offers the cheaper service also provides better quality. We have:

- $\nexists \tau_{mg}^{s,1} > 0$: Whatever the time value, passengers prefer patronizing operator j rather than operator k.

[9] We do not need to investigate also the case for $f_j^s < f_k^s$: this would provide no additional lesson, as results hold symmetrically.

- $\exists \tau_{mg}^{s,2,j} > 0$: Passengers with $\tau > \tau_{mg}^{s,2,j}$ are better off if they act as type 2 rather than waiting for firm j's Ships; the converse is true for those with $\tau < \tau_{mg}^{s,2,j}$.

- $\nexists \tau_{mg}^{s,2,k} > 0$: Whatever the time value, passengers prefer behaving as type 2 rather than patronizing operator k.

Clearly, the only cutoff time value, which matters as to the classification of passengers' behaviour, is now $\tau_{mg}^{s,2,j}$; hence, the following results are achieved:

- Firm j is patronized by travellers whose $\tau \in \left[0, \tau_{mg}^{s,2,j}\right)$.

- The (j,k) −option prevails for travellers whose $\tau \in \left(\tau_{mg}^{s,2,j}, +\infty\right)$.

Comparing the two scenarios, one may notice that the service frequency that is offered by the cheaper shipper is relevant at determining the cutoff time value which matters in the specific case. The cheaper operator is the one which attracts type-1 passengers; indeed, since the latter exhibit relatively low time value, smaller price is more important as compared to quality (hence, even if it is associated to smaller quality).

Firms' aggregate demand functions, for the scenario under scrutiny, write as

$$X_k^s = \frac{f_k^s}{f^s} \int_{\tau_{mg}^{s,2,j}}^{+\infty} \int_{\alpha} x^{s,2} h(\alpha)\, g(\tau)\, d\alpha d\tau \tag{11a}$$

and as

$$X_j^s = \int_{0}^{\tau_{mg}^{s,2,j}} \int_{\alpha} x_j^{s,1} h(\alpha)\, g(\tau)\, d\alpha d\tau + \frac{f_j^s}{f^s} \int_{\tau_{mg}^{s,2,j}}^{+\infty} \int_{\alpha} x^{s,2} h(\alpha)\, g(\tau)\, d\alpha d\tau \tag{11b}$$

for shipper k and j respectively.

A final observation may be derived from the analysis so far performed. Given prices and frequencies, what crucially determines passengers' behaviour and, as a result, their allotment between shippers, is the individual time value τ. The taste parameter α, instead, crucially drives the decision about the consumption volume, as already said. The different roles the two personal characteristics play are technically reflected in (10a) to (11b) by the circumstance that the integrals are taken over portions of the support of τ, but over the whole support of α.

2.2 The Shippers' Technologies

So far we have sketched out the essential characteristics of the demand side of the maritime ferry market. In the present Section, we describe the supply side of the industry and, in particular, the most important features of the shippers' technologies. We assume that the cost functions consist in three main components.

The first component is purely operational and is to be attributed to the used capacity. More precisely, it includes the costs associated to shipping personnel, passenger transferring, boarding and debarking operations and various related expenses. The utilized capacity, which we denote by K_j^s, represents the number of seats on firm j's ships which are occupied in season s. This capacity depends on both faced traffic and offered connection frequencies; indeed, it equals the ratio X_j^s/f_j^s. Observe that, for any given level of traffic, the larger the frequency, the smaller K_j^s; in the presence of increasing returns to scale, this involves higher per-passenger cost. The marginal cost of operation is assumed to be constant for either shipper; more precisely, it is given by a for firm E and $(a+\gamma)$ for firm I respectively. The hypothesis that the incumbent has larger marginal cost is in line with Cremer *et Alii* [6]; the latter capture the fact that equally skilled workers are frequently over-remunerated in public enterprises through the hypothesis that the latter pay a premium to their employees, an extra cost which appears as a budget component[10]. Therefore, the total per-year costs associated to the used capacity amount to $a\sum_s f_E^s K_E^s = a\sum_s X_E^s$ for the entrant and to $(a+\gamma)\sum_s f_I^s K_I^s = (a+\gamma)\sum_s X_I^s$ for the dominant operator respectively. Hence, this cost component proportionally increases in the traffic size.

The second component is specifically associated to the number of transfers performed with the available capacity, independently of whether the latter is fully occupied or remains (partially) idle. For instance, the activities related to mooring and sailing are executed at each travel, no matter how many passengers occupy the seats. In the long run, shippers adjust installed capacity according to the observed traffic, taking into account that, in the short run, they will benefit from seasonal flexibility in frequency; therefore, installed capacity is finally equivalent to $Sup\left\{K_j^l, K_j^h\right\} \equiv \overline{K}_j$, that is to the capacity that is actually used in the season where no excess is registered[11]. We assume that it generates a cost $\phi_j\left(\overline{K}_j\right)$ so that the overall associated burden amounts to $\phi_j\left(\overline{K}_j\right)\sum_s f_j^s$. We also suppose that it is $\phi_E > \phi_I$. Hence, while the incumbent is operationally less efficient than the entrant, it exhibits a cost advantage in terms of capital. This is easily explained if one recalls that, in the real-world sectors we refer to, the dominant enterprise is frequently the statutory provider, formerly or still public; as considered a guarantee for repayment, such a status helps obtain better financing conditions, which translates into lower cost of capital. This is relevant because, beyond some amount of frequencies, providing further transfers requires having larger fleets; under our assumption, disposing of bigger capacity is relatively more affordable for shipper I.

Finally, each firm bears a pure fixed cost F_j, mainly associated to the maintenance of ships and accessory equipment as well as to administration, advertising, insurance; hence, it is to be sustained even when no transfer is performed.

To summarize, each year, firm E's cost function writes as

$$TC_E = a\sum_s X_E^s + \phi_E\left(\overline{K}_E\right)\sum_s f_E^s + F_E,$$

[10] Estrin and de Meza [8] show that, in a mixed oligopoly providing a homogeneous product, private firms would not be in a position to produce positive outputs, at equilibrium, if the cost disadvantage of the State-owned firm did not exist.

[11] At the operational stage, the firm's cost function is, in fact, a short-run function. The size of capacity is a matter of long-run strategy and should be viewed as the first decision variable in a two-stage game in which enterprises anticipate the subsequent price-and-frequency choice.

whereas for the incumbent we have

$$TC_I = (a+\gamma)\sum_s X_I^s + \phi_I\left(\overline{K}_I\right)\sum_s f_I^s + F_I.$$

3 The Social Optimum

In the previous Sections, we have outlined the relevant demand and supply features of the maritime ferry market. As equipped with the information we have derived, we hereafter explore the first-best benchmark for the sector of our interest. More precisely, we characterize the prices and frequencies which maximize the utilitarian social welfare function, as given by the (unweighed) sum of aggregate consumer surplus and shippers' profits.

Aggregate surplus amounts to $TV = \sum_{s=l,h}\left(TV^{s,1} + TV^{s,2}\right)$; the addends in this expression measure the aggregate indirect utility of type-1 and type-2 passengers respectively. Total profits are equal to $\sum_{j=I,E}\pi_j = \sum_{j=I,E}\left(TR_j - TC_j\right)$, where TR_j represents firm j's total market revenues. As a result, the social welfare function writes as

$$W = TV + \sum_{j=I,E}\pi_j. \tag{12}$$

For the time being, providers are not required to break even; one may imagine that their participation in the market operation is ensured under the hypothesis that the government covers their extra costs (including the cost of capital) from its budget, by providing subsidies at no cost of public funds.

3.1 Preliminary Analysis

We facilitate the comprehension of the first-best benchmark by performing a preliminary analysis about the properties of the aggregate consumer surplus. The conclusions we attain to in this Section will prove useful along the subsequent investigation. We accomplish our task by separately studying the two scenarios already introduced in Section 2.

3.1.1 Scenario 1: $f_j^s > f_k^s$ and $p_j^s > p_k^s$

Our results about customers' behaviour suggest that, whenever firm j provides more transfers at larger price, as compared to shipper k, aggregate passenger surplus writes as

$$\begin{aligned} TV &= \sum_{s=l,h}\int_0^{\tau_{mg}^{s,2,k}}\int_\alpha \left[\alpha U\left(x_k^{s,1}\right) - \left(p_k^s + \frac{\tau}{2f_k^s}\right)x_k^{s,1}\right] h(\alpha)\, g(\tau)\, d\alpha d\tau \\ &+ \sum_{s=l,h}\int_{\tau_{mg}^{s,2,k}}^{+\infty}\int_\alpha \left[\alpha U\left(x^{s,2}\right) - \left(p^e + \frac{\tau}{2f^s}\right)x^{s,2}\right] h(\alpha)\, g(\tau)\, d\alpha d\tau. \end{aligned} \tag{13}$$

We initially study the price impact on TV. Differentiating the latter with respect to p_k^s, we obtain

$$\begin{aligned}\frac{\partial TV}{\partial p_k^s} &= -\int\limits_{\tau_{mg}^{s,2,k}}^{+\infty}\int\limits_{\alpha}\frac{f_k^s}{f^s}x^{s,2}h(\alpha)\,g(\tau)\,d\alpha d\tau - \int\limits_{0}^{\tau_{mg}^{s,2,k}}\int\limits_{\alpha}x_k^{s,1}h(\alpha)\,g(\tau)\,d\alpha d\tau \\ &= -\frac{f_k^s}{f^s}X^{s,2}+X_k^{s,1} = -X_k^s, \end{aligned} \tag{14a}$$

whereas differentiating with respect to the higher tariff p_j^s returns

$$\frac{\partial TV}{\partial p_j^s} = -\int\limits_{\tau_{mg}^{s,2,k}}^{+\infty}\int\limits_{\alpha}\frac{f_j^s}{f^s}x^{s,2}h(\alpha)\,g(\tau)\,d\alpha d\tau = -\frac{f_j^s}{f^s}X^{s,2} = -X_j^{s,2} = -X_j^s. \tag{14b}$$

(14a) and (14b) are the results one achieves by applying Roy's identity when customers have quasi-linear preferences: the (negative) variation, which is induced in the aggregate indirect utility by a unitary increment in price, equals the aggregate demand. Such findings are better understood if one recalls that price variations have a unitary impact on the marginal utility of the service for the $\alpha-$individual, if she behaves as type 1, and an impact equal to f_j^s/f^s, if she acts as type 2. This dictates the relevant demand by which aggregate consumer surplus decreases, as the tariff is augmented by one unit.

We next turn to the impact of frequencies on aggregate passenger surplus. Differentiating TV with respect to f_k^s and f_j^s yields

$$\begin{aligned}\frac{\partial TV}{\partial f_k^s} &= \int\limits_{0}^{\tau_{mg}^{s,2,k}}\int\limits_{\alpha}\frac{\tau}{2\left(f_k^s\right)^2}x_k^{s,1}h(\alpha)\,g(\tau)\,d\alpha d\tau \\ &+ \int\limits_{\tau_{mg}^{s,2,k}}^{+\infty}\int\limits_{\alpha}\frac{1}{(f^s)^2}\left[\frac{\tau}{2}-f_j^s\left(p_j^s-p_k^s\right)\right]x^{s,2}h(\alpha)\,g(\tau)\,d\alpha d\tau, \end{aligned} \tag{15a}$$

and

$$\frac{\partial TV}{\partial f_j^s} = \int\limits_{\tau_{mg}^{s,2,k}}^{+\infty}\int\limits_{\alpha}\frac{1}{(f^s)^2}\left[\frac{\tau}{2}-f_k^s\left(p_j^s-p_k^s\right)\right]x^{s,2}h(\alpha)\,g(\tau)\,d\alpha d\tau \tag{15b}$$

respectively. The results in (15a) and (15b) measure the change in aggregate consumer surplus, which is provoked by a unitary increase in frequency f_k^s and f_j^s respectively. Recall that the term $\tau/2\left(f_k^s\right)^2$ represents the effect caused on the marginal utility by the provision of the last transfer for the $\tau-$individual having taste parameter α and behaving as type 1; $\left[\tau/2-f_j^s\left(p_k^s-p_j^s\right)\right]/\left(f^s\right)^2$ has analogous meaning for a type-2 passenger. The rest of the right-hand side in the equality above is again the (negative of the) aggregate demand. Therefore, precisely as for the tariffs, whenever quality increases by one unit, aggregate consumer surplus is varied by an amount which equals the aggregate demand weighed by the change in consumer marginal utility[12].

3.1.2 Scenario 2: $f_j^s > f_k^s$ and $p_j^s < p_k^s$

For sake of completeness, we also consider the case where firm j still provides more connections, but sets a lower tariff, as compared to shipper k. However, we remark that varying the hypothesis about the price relation with respect to Scenario 1 induces qualitative changes neither in the analysis to be performed nor in the emerging outcomes. *Mutatis mutandis*, the previous considerations and interpretations are valid. Therefore, in what follows, we content ourselves with reporting the results for Scenario 2 and we abstain from further commenting.

Under the current assumptions about prices and frequencies, aggregate utility becomes

$$\begin{aligned} TV &= \sum_{s=l,h} \int_0^{\tau_{mg}^{s,2,j}} \int_\alpha \left[\alpha U\left(x_j^{s,1}\right) - \left(p_j^s + \frac{\tau}{2f_j^s}\right) x_j^{s,1}\right] h(\alpha)\, g(\tau)\, d\alpha d\tau \qquad (16) \\ &+ \sum_{s=l,h} \int_{\tau_{mg}^{s,2,j}}^{+\infty} \int_\alpha \left[\alpha U\left(x^{s,2}\right) - \left(p^e + \frac{\tau}{2f^s}\right) x^{s,2}\right] h(\alpha)\, g(\tau)\, d\alpha d\tau. \end{aligned}$$

The impact of prices p_k^s and p_j^s is expressed by the conditions

$$\frac{\partial TV}{\partial p_k^s} = -\frac{f_k^s}{f^s} X^{s,2} = -X_k^{s,2} = -X_k^s \qquad (17a)$$

and

$$\frac{\partial TV}{\partial p_j^s} = -\frac{f_j^s}{f^s} X^{s,2} + X_j^{s,1} = -X_j^s \qquad (17b)$$

respectively. Similarly, for frequencies f_k^s and f_j^s we obtain

$$\frac{\partial TV}{\partial f_k^s} = \int_{\tau_{mg}^{s,2,j}}^{+\infty} \int_\alpha \frac{1}{(f^s)^2} \left[\frac{\tau}{2} - f_j^s \left(p_k^s - p_j^s\right)\right] x^{s,2} h(\alpha)\, g(\tau)\, d\alpha d\tau \qquad (18a)$$

and

$$\begin{aligned} \frac{\partial TV}{\partial f_j^s} &= \int_0^{\tau_{mg}^{s,2,j}} \int_\alpha \frac{\tau}{2\left(f_j^s\right)^2} x_j^{s,1} h(\alpha)\, g(\tau)\, d\alpha d\tau \qquad (18b) \\ &+ \int_{\tau_{mg}^{s,2,j}}^{+\infty} \int_\alpha \frac{1}{(f^s)^2} \left[\frac{\tau}{2} - f_k^s \left(p_j^s - p_k^s\right)\right] x^{s,2} h(\alpha)\, g(\tau)\, d\alpha d\tau \end{aligned}$$

[12] In (14a) and (14b) as well as in (15a) and (15b), the derivatives of the bounds of the integrals cancel out as they are equivalent and have opposite sign. We omit them here as well as in all subsequent formulas where this is the case. They represent the effect that is induced by the variation in the relevant variable at the extensive margin, that associated to the shifting of the marginal customer. Instead, the terms we do report in the formulas express the impact which is caused at the intensive margin, the one concerning the infra-marginal consumers. For a discussion about effects at the extensive and intensive margin see the model about regulation in the postal sector by Billette de Villemeur *et Alii* [4].

respectively.

3.2 Per-Passenger Costs, Prices and Frequencies

Before characterizing the first-best prices and frequencies, we establish when and whether it is socially optimal that either firm operates, given the cost structures. For this purpose, we need to compare shippers' per passenger costs, as obtained by dividing variable costs by total traffics. More precisely, we have

$$PPVC_I^s = a + \gamma + \frac{f_I^s}{X_I^s}\phi_I \tag{19a}$$

for the incumbent and

$$PPVC_E^s = a + \frac{f_E^s}{X_E^s}\phi_E \tag{19b}$$

for the entrant[13]. For the industry per-passenger variable cost to be minimized, firm I should operate for all the values of X_I^s, X_E^s, f_I^s and f_E^s such that, given γ, ϕ_I and ϕ_E, it is

$$PPVC_I^s < PPVC_E^s \quad \Leftrightarrow \quad \gamma < \left(\frac{\phi_E}{K_E^s} - \frac{\phi_I}{K_I^s}\right). \tag{20}$$

Let us first explore the case where the difference $(\phi_E/K_E^s - \phi_I/K_I^s)$ in (20) is positive. With $\phi_I < \phi_E$, this requires $K_I^s > K_E^s$, which is quite a reasonable circumstance since firm I is the dominant operator of the sector. In this scenario, the entrant is preferred for all values of X_I^s, X_E^s, f_I^s and f_E^s such that γ exceeds the right-hand side of (20); in other words, the incumbent has to be sufficiently less efficient in terms of operation. In particular, the degree of relative operational inefficiency, beyond which firm E becomes more desirable, depends on the relative size of the costs of travels; indeed, for given capacities, the larger the gap between ϕ_E and ϕ_I, the greater the value of γ which triggers the entrant's preferability.

Conversely, whenever the difference $(\phi_E/K_E^s - \phi_I/K_I^s)$ is negative, that is capacity K_I^s is smaller than K_E^s, (20) cannot be met, meaning that it is better, from a social perspective, to solely entitle firm E with the provision of transportation service.

Finally, with $K_I^s = K_E^s \equiv \widetilde{K}$, (20) reduces to

$$\widetilde{K} < \frac{\phi_E - \phi_I}{\gamma},$$

suggesting that, when shippers' capacities are equally utilized, letting the incumbent be the only operator is socially preferable, as long as the level of used capacity is small enough. Firm E's activity becomes desirable beyond the threshold $(\phi_E - \phi_I)/\gamma$, when it complements shipper I's.

Applying the outcomes achieved in the preliminary analysis, one can easily show that, at the social optimum, marginal cost pricing entails for either operator. In other words, we have

$$p_I^{FB} = a + \gamma \tag{22a}$$

[13] In the first-best framework, we can abstain from considering the fixed cost components.

and

$$p_E^{FB} = a \tag{22b}$$

for firm I and E respectively, the superscript FB staying for first best. Observe that, as marginal costs are the same, whatever the season, the first-best tariffs remain constant all over the year. Moreover, they do not reflect the heterogeneity characterizing the population of customers; rather, the difference in prices solely expresses the difference in marginal costs, so that it is $p_I^{FB} > p_E^{FB}$. Though this might not be satisfactory on a distributional perspective, it is so on a pure efficiency ground.

Given the cost functions and applying the marginal cost pricing rules, the optimal scheduling for shipper $j = I, E$ in season $s = h, l$, which we denote by $f_j^{s,FB}$, is characterized by the condition

$$\frac{\partial TV}{\partial f_j^s} = \phi_j. \tag{23}$$

This is the equality between marginal cost of transfer ϕ_j and marginal aggregate indirect utility $\partial TV/\partial f_j^s$, which specifies as illustrated in the preliminary analysis for each of the potentially relevant cases. (23) suggests that, at the social optimum, shipper j should increase frequency until the additional benefit to consumers, which is generated by the last transfer, is fully offset by the additional cost it imposes on the provider. Various situations may realize, according to whether the incumbent offers more or fewer frequencies than the rival. Furthermore, differently from prices, first-best frequencies typically adjust on a seasonal basis as they are determined not only by the firms' technologies but also by the demand-side conditions of the market.

We can finally rely on the results established in Section 2 to analyse travellers' first-best allocation between operators. Whatever the relation between $f_I^{s,FB}$ and $f_E^{s,FB}$, the relevant cutoff time value is equal to $2\gamma f_E^{s,FB}$; passengers whose $\tau \in \left[0, 2\gamma f_E^{s,FB}\right)$ patronize the entrant, those with $\tau \in \left(2\gamma f_E^{s,FB}, +\infty\right)$ take the shipper setting sail next. As one may recall, this is so because, when the time value is little, the most relevant element resides in the price. Since shipper E offers the cheaper service, this is the operator type-1 customers prefer. Saving over time becomes more important as the penalty from waiting gets larger; then passengers are better off by departing as soon as possible, which leaves room to both shippers' activities. In this sense, operation by the dominant enterprise appears essentially beneficial to type-2 customers, to whom it provides additional frequency.

4 The Stackelberg Competition

As long as the viewpoint of the ideal planner is taken, pure profitability is no more relevant than it contributes to achieve the highest possible social welfare. In what follows, we modify the perspective of the analysis and suppose that operators select prices and frequencies in their best interests, so that their profits entail maxima.

In the industry under scrutiny, the dominant firm has the market leadership. After observing the latter's actions, the potential rival decides about its own accordingly. This price-and-frequency game is solved backward: firstly the follower's behaviour is derived, then the leader's policy is characterized.

Recall that, when we presented the model in Section 2, we classified the overall population of passengers into two categories, namely residents (market segment r) and non-residents (market segment n). At this stage of our analysis, this classification becomes relevant because we allow the firms to propose different prices to the two categories of customers. Observe that introducing the possibility of price discrimination is not arbitrary, it is rather backed by the observation of several such real-world situations. Conversely, the operators can only adjust frequencies on a seasonal basis. As will become clear, this asymmetric degree of flexibility between choice variables crucially affects the rate at which shippers can substitute away price and frequency. A double trade-off emerges: firstly, any price variation requires a frequency adjustment; secondly, the quality change to follow any such variation on either market segment needs to match the pricing policy proposed to the other group of travellers.

4.1 The Entrant's Price-and-Frequency Policy

We initially describe the second stage of the market game. We assume that, if firm E enters, it has market power, behaves as an active follower and reacts to the dominant enterprise's strategy through its price-and-frequency policy. This hypothesis involves that it enjoys some flexibility at adjusting its choice variables, which appears to be consistent with the real-world markets of the kind at stake.

Given the price $p_I^{s,i}$ and the frequency f_I^s, $i = r, n$ and $s = l, h$, that are chosen by the incumbent, enterprise E solves the problem

$$\underset{\substack{(p_E^{s,i}, f_E^s)_{s=h,l} \\ i=r,n}}{Max} \sum_{s,i} \left(p_E^{s,i} - a \right) X_E^{s,i} - \phi_E \sum_s f_E^s - F_E, \tag{24}$$

where the sum $\sum_{s,i} p_E^{s,i} X_E^{s,i} = \sum_{s,i} R_E^{s,i} = TR_E$ measures the total market revenues earned by shipper E.

The objective function in (24) is formulated so that operation in both market segments and seasons is taken into account. Nevertheless, rationality involves that the firm serves only one category of customers or is only active in one season of the year, in the event that it bears losses by doing otherwise. Hence, quantities are null whenever referred to no-entry scenarios. The most likely such scenario appears to be the low season ($s = l$) when, due to the scarcity of occasional travellers and, in particular, of tourists, the bulk of traffic resides in the frequent passengers, typically the residents of the islands. The available market may then be too small for the entrant's activity to prove profitable; therefore, the shipper may decide to stay temporarily out.

Conditional on entry, the first-order condition for a maximum of the profit function with respect to price $p_E^{s,i}$, $i = r, n$ and $s = l, h$, writes as

$$\left(p_E^{s,i} - a \right) \frac{\partial X_E^{s,i}}{\partial p_E^{s,i}} = -X_E^{s,i},$$

evidencing that the provider only cares about the reduction which a price increase induces in its own demand and so in its own profits[14]. Grouping and rearranging terms and defining the (absolute value of the) elasticity of demand $X_E^{s,i}$ to price $p_E^{s,i}$ as $\varepsilon_E^{(s,i)(s,i)} \equiv \left(p_E^{s,i}/X_E^{s,i}\right)\left(-\partial X_E^{s,i}/\partial p_E^{s,i}\right)$, we can transform the previous equality into

$$\frac{p_E^{s,i} - a}{p_E^{s,i}} = \frac{1}{\varepsilon_E^{(s,i)(s,i)}}. \tag{25a}$$

(25a) measures the firm's markup, the ratio between profit margin and price, which is inversely proportional to the demand elasticity. Since the entrant behaves as a monopolist *vis à vis* the residual demand, that is the market share which is not served by the dominant operator, the inverse elasticity rule holds: the shipper is more wary of the perverse impact of a high price on consumption when travellers react to a price increment by largely reducing their demand for the service.

Having the provider choosing the connection frequency together with the monetary charge does not involve any variation in its optimal pricing *rule*; nevertheless, the price itself does depend on the frequency[15]. The first-order condition with respect to f_E^s, $s = l, h$, is given by

$$\sum_i \left(p_E^{s,i} - a\right) \frac{\partial X_E^{s,i}}{\partial f_E^s} = \phi_E, \tag{25b}$$

which suggests that, at the firm's optimum, the variation induced by a frequency increase in the profit margins over all the marginal traffic units on both market segments must equal the cost of the last provided transfer[16]. Observe that, by the first-order condition with respect to $p_E^{s,i}$, the left-hand side of (25b) rewrites as $\sum_i X_E^{s,i}\left(\partial X_E^{s,i}/\partial f_E^s\right) / \left(-\partial X_E^{s,i}/\partial p_E^{s,i}\right)$, which is a weighed sum of the demands on the two market segments. Interestingly, the weights are given by the aggregate substitution rates between money and quality, given the traffic faced by shipper E; such rates measure how much additional frequency the enterprise needs to provide, as a compensation for a price increase, in order to keep its demand unchanged.

Combining (25a) and (25b), we obtain

$$\sum_i R_E^{s,i} \frac{\eta_E^{(s,i)(s)}}{\varepsilon_E^{(s,i)(s,i)}} = f_E^s \phi_E, \tag{26}$$

where $\eta_E^{(s,i)(s)} \equiv \left(f_E^s/X_E^{s,i}\right)\left(\partial X_E^{s,i}/\partial f_E^s\right)$ measures the elasticity of demand $X_E^{s,i}$ to fre-

[14] The first-order condition characterizes the reaction function $p_E^{s,i}\left(p_I^{s,i}\right)$ that gives the optimal choice of $p_E^{s,i}$ as a function of the incumbent's price $p_I^{s,i}$.

[15] If quality did not matter, things would be somewhat simpler. To see this, notice that, if the follower offers a positive amount of transportation service, then it should set $p_E^{s,i} = p_I^{s,i}$. Indeed, for each price $p_I^{s,i}$, firm E supplies the amount of output that maximizes its profits, taking the incumbent's price as given. Therefore, its reaction function to shipper I's policy coincides with with the competitive supply curve. Anticipating this behaviour, the leader selects its optimal price facing the residual demand curve, that is the curve which is left after subtracting the follower's demand from the overall one (see Varian [19] for further details).

[16] Once again, the first-order condition characterizes the reaction function $f_E^s\left(f_I^s\right)$ that gives the optimal choice of f_E^s as a function of the incumbent's frequency f_I^s.

quency f_E^s. (26) identifies the relationship between frequency and price elasticities at the entrant's optimum. In particular, the left-hand side of the equality is a weighed sum of the revenues shipper E obtains from the tickets sold on the two market segments, the weights being the ratios between frequency elasticity and price elasticity for each segment. This sum has to equal the total cost of providing transfers by means of the available fleet, which appears in the right-hand side of (26).

4.2 The Incumbent's Price-and-Frequency Policy

We next investigate the first stage of the market game. The incumbent determines the optimal values of $p_I^{s,i}$ and f_I^s by solving the programme

$$\underset{\substack{(p_I^{s,i}, f_I^s)_{s=h,l} \\ i=r,n}}{Max} \sum_{s,i} \left[p_I^{s,i} - (a+\gamma)\right] X_E^{s,i} - \phi_I \sum_s f_I^s - F_I, \tag{27}$$

where, as for the entrant, the sum $\sum_{s,i} p_I^{s,i} X_I^{s,i} = \sum_{s,i} R_I^{s,i} = TR_I$ expresses the total revenues obtained by shipper I.

Since, in the industry under discussion, the dominant firm behaves as a leader, while deciding about its own strategy, it anticipates the impact to be caused on the policy of the rival, if the latter accesses the market. It follows that the first-order condition with respect to price $p_I^{s,i}$ is given by

$$\left[p_I^{s,i} - (a+\gamma)\right] \frac{dX_I^{s,i}}{dp_I^{s,i}} = -X_I^{s,i},$$

where $dX_I^{s,i}/dp_I^{s,i} \equiv \partial X_I^{s,i}/\partial p_I^{s,i} + \left(\partial X_I^{s,i}/\partial p_E^{s,i}\right)\left(dp_E^{s,i}/dp_I^{s,i}\right)$ is the total derivative of demand $X_I^{s,i}$ with respect to price $p_I^{s,i}$[17]. Next define $\widehat{\varepsilon}_I^{(s,i)(s,i)} \equiv \left(p_I^{s,i}/X_I^{s,i}\right)\left(-dX_I^{s,i}/dp_I^{s,i}\right)$ the (absolute value of the) elasticity of demand $X_I^{s,i}$ to price $p_I^{s,i}$, accounting for both direct and strategic effect of variations in $p_I^{s,i}$ on $X_I^{s,i}$. In order to avoid confusion, in what follows, we name this elasticity as *adjusted elasticity.* The latter allows to re-express the condition above as

$$\frac{p_I^{s,i} - (a+\gamma)}{p_I^{s,i}} = \frac{1}{\widehat{\varepsilon}_I^{(s,i)(s,i)}}, \tag{28a}$$

which suggests that the Lerner index is inversely proportional to the price elasticity which embodies the strategic effect operating through the rival price.

Turning next to the quality decision, the first-order condition with respect to f_I^s, $s = l, h$, writes as

$$\sum_i \left[p_I^{s,i} - (a+\gamma)\right] \frac{dX_I^{s,i}}{df_I^s} = \phi_I, \tag{28b}$$

where we have set $dX_I^{s,i}/df_I^s \equiv \partial X_I^{s,i}/\partial f_I^s + \left(\partial X_I^{s,i}/\partial f_E^s\right)(df_E^s/df_I^s)$ the total derivative of

[17] In the text, we implicitly refer to the case where the total derivative is negative, that is where the direct effect of $p_I^{s,i}$ on $X_I^{s,i}$ dominates the strategic one, which operates through the rival price $p_E^{s,i}$.

demand $X_I^{s,i}$ with respect to frequency f_I^s[18]. (28b) establishes the equality between the cost of the last provided transfer and the benefit it induces, that is the associated increase in the profitability of the marginal traffic units. Relying on the first-order condition with respect to $p_I^{s,i}$, we are able to equivalently express the left-hand side of (28b) as $\sum_i X_I^{s,i} \left(dX_I^{s,i}/df_I^s\right) \left(-dX_I^{s,i}/dp_I^{s,i}\right)$. This is a sum of the demands faced by the incumbent on the two segments, each weighed by the rate at which, in the aggregate, per-segment monetary charge and seasonal quality can be substituted away for demands not to vary. In other words, these rates measure how the dominant enterprise has to reschedule, when increasing the tariffs, in order to preserve the initial demands, given the effects provoked in the competitor's policy.

Combining (28a) and (28b), we obtain

$$\sum_i R_I^{s,i} \frac{\widehat{\eta}_I^{(s,i)(s)}}{\widehat{\varepsilon}_I^{(s,i)(s,i)}} = f_I^s \phi_I. \tag{29}$$

Sticking on the terminology previously introduced, $\widehat{\eta}_I^{(s,i)(s)} \equiv \left(f_I^s/X_I^{s,i}\right)\left(dX_I^{s,i}/df_I^s\right)$ is the *adjusted elasticity* of demand $X_I^{s,i}$ to frequency f_I^s. Notice the similarity between (29) and (26). The left-hand side of (29) is the weighed sum of the revenues obtained on the two market segments, the weights being the ratios between frequency and price adjusted elasticity for each of the two segments. Precisely as for the entrant, this sum has to equal the total cost the firm bears in season s for the provision of transfers, showing up in the right-hand side of (29)[19].

The analysis so far performed reveals that the entrant and the incumbent cling on similar pricing-and-scheduling rules. Substantially, either of them is in a monopolistic position with respect to some portion of the overall market. A sole essential difference is found in the optimal conditions of the two operators: they do not embody the same elasticities. In particular, for the industry leader, relevant elasticities are those adjusted for the relation with the rival's choice variables, so that the impact to be caused on the competitor's decisions by its own is accounted for.

The results we have achieved suggest that, whenever operation in the maritime ferry industry is concentrated in the hands of one or few profit-maximizing shippers, the exercise of market power may prove to be a serious issue. Even if Stackelberg competition takes place among strategic providers, it does not ensure that sufficient connections are spontaneously provided at affordable prices. On the opposite, the outcome yielded by the market forces violates the territorial continuity principle, which calls for corrective intervention.

[18] In the text, we implicitly refer to the case where the total derivative is positive, that is where the direct effect of f_I^s on $X_I^{s,i}$ dominates the strategic one, which operates through the rival quality f_E^s.

[19] When firm E does not enter the market, so that the incumbent preserves a monopolistic position *vis-à-vis* the passengers, the total derivatives in the previous formulas reduce to the partial derivatives and the adjusted elasticities to the standard elasticities.

5 The Partial Regulation Regime

In the previous Section, we have concentrated on the pricing and scheduling policies that would be entailed if both shippers were free to behave according to their profit-maximizing strategies, hence in the absence of any regulatory constraint. We have ascertained that the market equilibrium is hardly satisfactory from a social perspective. The problem is particularly concerning during the low season, when service supply is likely to be purely monopolistic and demand essentially generated by frequent travellers, such as the residents; as the latter represent the more captive category of passengers, they are especially penalized by the drawbacks of insularity.

In order to cope with this issue, at the European level it has been established that, if necessary, "public service obligations may be imposed or public service contracts may be concluded" (European Council, art.4, [13]) for regular services to, from and between the islands. In particular, allowed PSOs are requirements about (among other elements) regularity, continuity, frequency and rates to be charged, that are justified "in cases where the operation of market forces would not ensure a sufficient service level" (European Commission, art.9, [12]). Therefore, the firms' strategic variables which matter in our stylized maritime ferry industry may legitimately go subject to regulatory control.

Compatibility with the common market has been ensured by ruling that PSCs for medium and big islands have to be awarded by public tendering; the winner is supposed to be the shipper bidding the "lowest financial compensation", which consists in the costs of operation that are uncovered by market revenues, together with a return on capital. On the other hand, as we said in the Introduction, a simplified procedure is allowed for the small islands (European Commission [10]), for which PSCs can be awarded on the basis of calls for expressions of interest. In what follows, we look at the case where the shipper subject to public service constraints (whether in the form of PSC or of PSOs) is the dominant firm and we characterize the optimal regulatory policy accordingly. This does not mean that, *a priori*, one can rule out that operators, other than the incumbent, are compelled to social service duties. For instance, in a situation similar to the one reproduced in our model, if an auction takes place, either shipper may well win, as both firms have relative cost advantages and disadvantages. However, the scenario we choose to concentrate on is less arbitrary that it may look at a first glance. Indeed, it might be a conscious decision of firm E to express no interest for social services, in order to preserve the freedom of being active or not to its best convenience[20].

As the contract is executed, a *partial regulation regime* arises: while the dominant shipper is bound to obligations, the entrant behaves as a pure profit-maximizer, just like in the unregulated market. We model this scenario by envisaging a planning regime in which the regulator can directly control the relevant price and frequency choices of firm I. The optimal regulatory policy we hereafter characterize constitutes an essential benchmark, as it is derived under the hypothesis that the authority is perfectly informed about both technologies and market conditions. Observe that a context where the regulated incumbent (eventually) competes with an unregulated follower also reproduces those real-

[20] Recall that the follower has flexibility odds with respect to the leader.

world situations where contracts previously signed with (former) statutory monopolists are still in force, under the 1997 Guidelines of the European Commission [12], even if new operators have turned up in the meanwhile[21] .

We also assume that the regulator lets the incumbent (at least) balance the budget. This modelling device accommodates both environments where transfers from the government to the economic agents are not allowed and situations where the regulated firm can be awarded a subsidy to cover the realized deficits, as in the European countries[22]. Indeed, it is easy to show that the solutions yielded by the two procedures are *qualitatively* equivalent, once the shadow cost associated to the budget constraint is replaced by the social cost of transferring money to the enterprise.

Turning to the formal analysis, partial regulation is meant to pursue two essential objectives, namely the provision of a sufficient number of connections in each season as well as the charge of reasonably low prices to all passengers and, in particular, to the residents, who deserve prior consideration. Hence, a regulatory policy consists in a quadruple of tariffs $\left(p_I^{s,i}\right)_{s=h,l,\ i=r,n}$ and in a pair of frequencies $(f_I^s)_{s=h,l}$ to be offered by shipper I. We assume that each category of passengers is attributed a seasonal weight $\omega^{s,i} \geq 1$, $s = h, l$, $i = r, n$; more precisely, we suppose that $\omega^{s,r} \geq \omega^{s,n} = 1$, $s = h, l$, which is meant to capture the special care that is devoted to the residents, relatively to the non-residents[23]. In definitive, in the context under scrutiny, the relevant welfare function is given by the weighed sum

$$WW = \sum_{s,i} \omega^{s,i} TV^{s,i} + \pi_I + \pi_E. \tag{30}$$

The optimal complete-information partial regulatory policy $\left(p_I^{s,i,PR}, f_I^{s,PR}\right)_{s=h,l,\ i=r,n}$, the superscript PR staying for *partial regulation*, is the solution to the programme

$$\begin{gathered} \underset{\left(p_I^{s,i}, f_I^s\right)_{\substack{s=h,l \\ i=r,n}}}{Max} \quad WW \\ \text{subject to} \\ \pi_I \geq 0. \end{gathered} \tag{31}$$

Notice that the follower's entry decision and its price-and-frequency strategy are taken as given: it is known that, after observing the leader's policy, conditional on entry, firm E will cling on the optimal private rules in (25a) and (25b). (31) is solved anticipating this behaviour. The ability to internalize the impact of the incumbent's decisions on the rival's may prove of crucial importance; indeed, while delegating the execution of the optimal

[21] Italy is one of the countries where the pre-existing contract is still ongoing as validity has been preserved till expiration: signed with the Gruppo Tirrenia S.p.A., it is destined to end in 2008. Other examples are given by Germany, where the contract currently in force regulates the service for the period 1997-2011, and by the UK, where the contract for the service provision between Clyde and the islands started in 1995 and no deadline is agreed upon.

[22] For instance, subventions are currently adopted in the Italian shipping industry, where the Gruppo Tirrenia S.p.A. receives yearly subsidies, including both the extra-costs of operation and the remuneration of the invested capital.

[23] In general, we shall refer to the case where $\omega^{s,r} > \omega^{s,n} = 1$. However, we allow as well for the weight $\omega^{s,r}$ to be unitary for reasons which will become clear at later stage.

policy to the regulated firm, the regulator is in fact taking over the market leadership from the latter *vis-à-vis* shipper E. It is through this channel that the regulatory intervention affects the access to the industry and that indirect discipline is exerted on the relevant choices at the competition stage.

The Lagrangian of (31) writes as

$$L^{PR}\left(p_I^{s,i}, f_I^s; \lambda_b\right)_{\substack{s=h,l \\ i=r,n}} = \sum_{s,i} \omega^{s,i} TV^{s,i} + (1+\lambda_b)\,\pi_I + \pi_E,$$

λ_b being the multiplier associated to the incumbent's budget constraint. The (constrained) optimality condition for the price $p_I^{s,i}$, $s = h, l$, $i = r, n$, in the partial regulation regime under scrutiny, is given by

$$\frac{p_I^{s,i} - (a+\gamma)}{p_I^{s,i}} = \frac{1}{E_I^{(s,i)(s,i)}} \left[1 + \left(\frac{1}{1+\lambda_b}\right) \frac{1}{X_I^{s,i}} \left(\frac{\partial \pi_E}{\partial p_I^{s,i}} - \omega^{s,i} X_I^{s,i}\right)\right], \tag{32a}$$

where $E_I^{(s,i)(s,i)}$ measures the (absolute value of the) elasticity of demand $X_I^{s,i}$ to price $p_I^{s,i}$. In particular, $E_I^{(s,i)(s,i)}$ is equal to the adjusted elasticity $\widehat{\varepsilon}_I^{(s,i)(s,i)}$, if it is anticipated that firm E will be active on the market, as it is likely to be the case during the high season; on the other hand, it equals the standard elasticity $\varepsilon_I^{(s,i)(s,i)}$, if monopoly by shipper I is expected, as in the low season, when demand is limited and entry discouraged. Notice that the term $\partial \pi_E / \partial p_I^{s,i}$, when larger than zero[24], expresses the positive impact induced by an increase in the tariff $p_I^{s,i}$ on the competitor's welfare; on the other hand, $-\omega^{s,i} X_I^{s,i}$ represents the negative effect of such an increase on the (social value of the) surplus of passengers belonging to category i. This is the immediate consequence of the service obligations pending on the firm: in line with the European rules, the latter is forced to performances which, if considering its own commercial interest, it would not assume, as (28a) and (28b) show. Observe that the term $\partial \pi_E / \partial p_I^{s,i}$ contributes to keep the incumbent's markup large, whereas $-\omega^{s,i} X_I^{s,i}$ tends to make it small; the incumbent is forced to a negative margin on market segment i in the event that the welfare of $i-$customers is sufficiently socially relevant during the season at stake ($\omega^{s,i}$ large enough).

The size of the margin given up to the regulated operator, hence the level of the tariff it has to charge and, even more, the way the latter compares to the competing price, are of crucial importance in terms of passengers' allotment between shippers. To see this, recall from Section 2 that passengers of type 1 patronize the shipper which charges the lower tariff; moreover, the people who live on the islands typically take a type-1 behaviour, though this does not constitute a general rule. Let us suppose, for the time being, that this is actually the case; let us as well assume that firm E enters the market, as it might be in season h. If it turns out that $p_I^{h,r,PR} < p_E^{h,r}$, because society is particularly concerned with the surplus of the residents, the latter all accrue to the incumbent, as a result of the regulatory policy. This allocation might be very different from the one which would arise if the industry were unregulated. Indeed, it might well happen that, when faced with an unregulated leader, the follower is able to fix its tariff (slightly) below the one

[24] Clearly, this derivative disappears when entry does not occur.

charged by the rival, by exploiting its advantage in terms of operational costs; like this, at the unregulated market equilibrium with entry, it would be firm E, rather than the incumbent, to conquest type-1 customers.

It is remarkable that, as soon as a second unregulated operator enters the industry, a relatively larger markup is attributed to the incumbent[25]. This suggests that the benefit generated by the competitor's activity is twofold: firstly, it supplies transportation services to passengers; secondly, in its presence, it becomes easier to cover the costs of the regulated firm.

The role that is plaid by the entrant is more evidently highlighted by studying (32a) for $\omega^{s,i} = 1$ and $\lambda_b = 0$. The first condition means that no specific relevance is attributed to the passengers in category i during season s; in fact, this is what we have previously assumed for the non-residents $(i = n)$, whatever the season. The second condition means that there is no break-even concern with shipper I; clearly, this is a limit case, but it helps intuition. Supposing that firm E does enter the market, (32a) reduces to

$$\frac{p_I^{s,i} - (a+\gamma)}{p_I^{s,i}} = \frac{1}{X_I^{s,i}} \frac{\partial \pi_E}{\partial p_I^{s,i}} \frac{1}{\widehat{\varepsilon}_I^{(s,i)(s,i)}},$$

which shows that the regulated markup would be larger than zero, even in the absence of budget preoccupations[26]. More precisely, firm I's margin is positively related to the competitor's; to see this, we reformulate the previous condition as

$$\left[p_I^{s,i} - (a+\gamma)\right] \left| \frac{dX_I^{s,i}}{dp_I^{s,i}} \right| = \left(p_E^{s,i} - a\right) \frac{\partial X_E^{s,i}}{\partial p_I^{s,i}}. \tag{33a}$$

The margin $\left[p_I^{s,i} - (a+\gamma)\right]$ in the left-hand side of (33a) represents the distortion associated to the variation induced in shipper I's demand by a unit increase in the regulated price, $\left|dX_I^{s,i}/dp_I^{s,i}\right|$ measuring the (absolute value of the) change in units of traffic for the firm. The margin $\left(p_E^{s,i} - a\right)$ in the right-hand side is, instead, the distortion following to the variation caused in firm E's demand by the same price increase, $\partial X_E^{s,i}/\partial p_I^{s,i}$ being the change in units of traffic for the entrant. The regulator equals the two distortions in order to balance, at the margin, the benefit granted to the competitor (which encourages entry and activity) with the cost of giving up resources to the regulated agent. Observe that, if the cross-price effect $\partial X_E^{s,i}/\partial p_I^{s,i}$ is important, the negative impact on firm I's demand is largely compensated by the positive impact on the demand faced by the entrant; in this event, there is no need to significantly increase the regulated price, hence also the rival price remains relatively contained[27].

The case for $\lambda_b > 0$, which generalizes the limit scenario we have been investigating, calls for the incumbent's margin to be, *ceteris paribus*, even larger; however, since the budget constraint of the regulated operator is binding, no rent is awarded, as the margin

[25] Since we have $\widehat{\varepsilon}_I^{(s,i)(s,i)} < \varepsilon_I^{(s,i)(s,i)}$, it is $1/\widehat{\varepsilon}_I^{(s,i)(s,i)} > 1/\varepsilon_I^{(s,i)(s,i)}$.

[26] In case of entry, the incumbent would obtain zero margin only if the entrant's profits were not sensitive at all to variations in the leader's price. This would require no substitutability between the services provided by the two shippers, which might be seen as a limit case of our model.

[27] Prices are strategic complements.

increase is rather destined to cover the costs of operation.

So far we have concentrated on the entry scenario. We now study what the optimal policy is when, at the design stage, the regulator anticipates that, after observing the leader's prices and frequencies, the follower will prefer not to operate and so competition will not take place (for instance, in season l). It is straightforward to check that, with unitary weight and no entry, (32a) collapses onto the Ramsey-Boiteux pricing formula, which is found by maximizing unweighed social welfare under the budget constraint of the regulated monopolist. More generally, with $\omega^{s,i} > 1$, the incumbent's markup on segment i is positive if and only if $(1 + \lambda_b) > \omega^{s,i}$. To interpret this inequality, it is useful to recall the Lagrangian of (31): as the latter reveals, ensuring that the budget of the shipper is balanced amounts to attributing a weight equal to $(1 + \lambda_b)$ to its profits in the overall welfare of society. The operator is granted a positive margin when this weight exceeds the one attached to the surplus of the customers in category i : it would cost more to have the firm further reducing the price than society would gain from such a reduction in terms of benefit to these passengers. The margin is, instead, negative in the converse case. Clearly, absent governmental transfers, the operator cannot be forced to lose money on both categories of passengers all over the year, as this would prevent breaking-even.

This last consideration suggests that cross-subsidization across segments and seasons is a crucial component of the pricing policy in the ferry industry, whether entry occurs or not and subventions are allowed or not. Indeed, if the regulated shipper's extra costs can be financed by transfers from the government, cross-subsidization can help contain the amount of funds to be devoted to coverage. On the other hand, when budget balance is required, long-run viability can reasonably be ensured by allowing the regulated firm to make money from the tickets sold to the non-residents, whenever it is bound to bear losses *vis-à-vis* the residents, or to gain in the high season as a compensation for the low-season deficit. Notice that competition may facilitate this practice because, as previously pointed, in the presence of a second provider, the regulated shipper may be granted larger markup than it might otherwise obtain. Furthermore, the circumstance that the agents' costs are to be recovered on a yearly basis, rather than in each season, involves that cross-subsidization may contribute to smooth the scheduling path all over the year.

We now precisely turn to the partial regulation frequency rule; for season $s = h, l$, it writes as

$$\phi_I - \sum_i \left[p_I^{s,i} - (a + \gamma) \right] \frac{dX_I^{s,i}}{df_I^s} = \frac{1}{1 + \lambda_b} \left(\sum_{s,i} \omega^{s,i} \frac{\partial TV^{s,i}}{\partial f_I^s} + \frac{\partial \pi_E}{\partial f_I^h} \right). \tag{34a}$$

Similarly to what we said about tariffs, under the regime in analysis, it is not enough to consider the direct impact of scheduling on the incumbent's profits, as expressed by the left-hand side of (34a), for determining the optimal amount of connections. It is as well necessary to account for the effect on the customers' and the competitor's surplus, appearing in the right-hand side of (34a), which the incumbent would not do if unregulated. Since frequencies are provided in the same number to both residents and non-residents, not only the former but also the latter are positively concerned by frequency variations

$\left(\partial TV^{s,i}/\partial f_I^s > 0,\ \forall s,i\right)$. Conversely, an increase in the number of transfers supplied by the incumbent, which makes firm I's service more attractive, reduces shipper E's profits $\left(\partial \pi_E/\partial f_I^s < 0\right)$. Overall, the right-hand side of (34a) measures the net impact that a unitary increase in the incumbent's frequency provokes on the welfare of the other economic agents, as deflated by the cost imposed by the budget constraint of the regulated operator.

Let us now study (32a) together with (34a), in order to highlight some interesting points about the weights $\omega^{s,i}$. The opportunity of differentiating and adjusting the latter according to the seasonal market situation is of crucial relevance. As suggested by the conditions previously said, the regulator can play weights against changes in firm E's profits. In particular, in the high season, the presence of the entrant is, to some extent, a guarantee of price competition and service provision; this limits the need to attribute large weight to the residents' surplus in the social welfare function and the regulator might want to set $\omega^{h,r} = 1$[28]. Conversely, territorial continuity and price affordability become more a concern in the season when demand is little and the incumbent is likely to operate as a monopolist; in the absence of spontaneous market forces, the operator's actions have to be especially constrained for protecting the customers' right to travel at affordable prices. This may trigger the choice of a large weight.

To sum up, the optimal complete-information partial regulatory policy, identifiable in the pricing and scheduling rules in (32a) and (34a), has been characterized as the one which maximizes social welfare, when a weight (weakly) larger than one is attributed to the weaker category of passengers and the shipper which is bound to social service duties is let balance the budget.

At this stage of the investigation, we wonder whether and under which circumstances the policy we have been designing can be implemented by forcing the operator to satisfy some constraints in terms of prices and frequencies to be offered. The relevance of this point becomes evident if one considers that many of the contracts which were signed years ago with the operators at the time in activity (usually, in monopoly), and that are preserved in force still now by the European norms, embody constraints of this kind. In practice, several such agreements define both the tariffs and the number of transfers the entrusted enterprise has to apply; formally speaking, this means that the firm faces the constraints $p_I^{s,i} = P^{s,i}$ and $f_I^s = F^s$, $s = h, l$, $i = r, n$. Reasonable concerns arise about the consequences that might be induced by such contractual duties, whenever the latter are not inspired to criteria of (constrained) social optimality and prove to be arbitrary.

In what follows, we address the issue above by investigating a more general scenario, in which inequality (rather than pure equality) constraints are allowed for. Observe that this does not halter the analysis as the real-world situations we have previously described constitute a limit case of the environment we prefer to consider. In particular, we suppose that the regulator requires the targeted shipper to charge tariffs larger than some specific threshold, which amounts to meeting the set of constraints

$$p_I^{s,i} \leq P^{s,i},\ s = h, l,\ i = r, n. \tag{35a}$$

[28] This explains why we have initially allowed seasonal weights for residents to be unitary.

We also assume that the operator has to satisfy the pair of frequency-floors

$$f_I^s \geq F^s, \ s = h, l, \tag{35b}$$

that is provide (at least) a quantity F^s of transfers in either season. Therefore, in the presence of these obligations, shipper I's programme writes as

$$\underset{\left(p_I^{s,i}, f_I^s\right)_{\substack{s=h,l \\ i=r,n}}}{Max} \quad \pi_I$$

$$\text{subject to} \tag{36}$$

$$\text{(35a) - (35b)}^{29}.$$

Denote $\lambda_p^{s,i}$ and λ_f^s the multipliers associated to the price-constraints and to the frequency-constraints respectively in the Lagrangian of (36) and set the derivative of the latter with respect to $p_I^{s,i}$ equal to zero; this yields the following expression for the incumbent's markup

$$\frac{p_I^{s,i} - (a + \gamma)}{p_I^{s,i}} = \frac{1}{E_I^{(s,i)(s,i)}} \left(1 - \frac{\lambda_p^{s,i}}{X_I^{s,i}}\right), s = h, l, \ i = r, n. \tag{37a}$$

Ceteris paribus, the relative margin in (37a) is decreasing in the multiplier; indeed, the larger $\lambda_p^{s,i}$, the more stringent the price-limit, hence the lower the price to be charged to passengers in category i. If $\lambda_p^{s,i}$ is important enough, the cap forces the incumbent to lose money on the specific market segment. Furthermore, the condition for (constrained) optimality with respect to f_I^s is given by

$$\sum_i \left[p_I^{s,i} - (a + \gamma)\right] \frac{dX_I^{s,i}}{df_I^s} = \phi_I - \lambda_f^s, \ s = l, h^{30}, \tag{37b}$$

suggesting that the sum of the profitability of the marginal traffic units on the two market segments has to equal the net marginal cost of frequency, which is given by the difference between the technological cost ϕ_I of the last provided transfer and the shadow cost λ_f^s of the frequency-floor. For λ_f^s sufficiently large, one has $\phi_I - \lambda_f^s < 0$, involving that the margin is negative (at least) on one market segment and the shipper is forced to provide so many connections, that the "overall" profitability of the last transfer is negative. This scenario is only feasible if the regulated firm is awarded a subsidy when it runs a deficit by providing the service. Conversely, $\phi_I - \lambda_f^s$ can never be negative in environments where governmental transfers are not allowed.

The seasonal price-bounds and frequency-floors respond to criteria of (constrained) social optimality if and only if they implement the policy $\left(p_I^{s,i,PR}, f_I^{s,PR}\right)_{s=h,l, \ i=r,n}$. For

[29] It is clear that, as previously said in the text, as soon as the (weak) inequality constraints are binding, the programme has the same solution it would achieve under equality constraints.

[29] As soon as the (weak) inequality constraints are binding, the programme has the same solution it would achieve under equality constraints.

[30] The total derivative $dX_I^{s,i}/df_I^s$ reduces to the partial derivative $\partial X_I^{s,i}/\partial f_I^s$ in the no-entry scenarios.

this to be the case, the constraints need to be structured so that the associated multipliers are (simultaneously) given by

$$\lambda_p^{s,i} = \frac{1}{1+\lambda_b}\left(\omega^{s,i}\ X_I^{s,i} - \frac{\partial \pi_E}{\partial p_I^{s,i}}\right),\ s = h, l,\ i = r, n, \tag{38a}$$

and

$$\lambda_f^s = \frac{1}{1+\lambda_b}\left(\sum_{s,i}\omega^{s,i}\frac{\partial TV^{s,i}}{\partial f_I^s} + \frac{\partial \pi_E}{\partial f_I^s}\right),\ s = h, l. \tag{38b}$$

Interesting conclusions can be drawn about the links among relevant multipliers and market competition by analysing the equivalence conditions above in details.

Firstly, (38a) and (38b) suggest that the multipliers $\lambda_p^{s,i}$ and λ_f^s should increase in the weights (and, more generally, in the net marginal benefit of the economic agents other than the regulated firm): *ceteris paribus*, the larger the privilege attributed to the residents, the more stringent the constraints should be for this tutelage to be guaranteed.

Secondly, the shadow values $\lambda_p^{s,i}$ and λ_f^s should decrease in λ_b : when balancing the regulated firm's budget proves to be hard in the partial regulation regime, it is not efficient having the shipper set very low prices and be too generous at scheduling; hence, the equivalent price-bound and frequency-floor should not be extremely tight.

Finally, it turns out that, as soon as a competitor operates in the industry, $\lambda_p^{s,i}$ and λ_f^s have to be chosen smaller than they would be, *ceteris paribus*, for a monopoly ($-\partial \pi_E / \partial p_I^{s,i} < 0$ and $\partial \pi_E / \partial f_I^s < 0$). This policy is necessary to account for the effect induced by the social obligations on the profits of the rival shipper, hence on the contribution the latter brings about to the generation of utility by providing its services. Therefore, if the regulator omits to embody the implications of market competition in the constraints, the tariffs may prove excessively low and the number of transfers too large with respect to what criteria of (constrained) social optimality would require. This risk typically arises with the ongoing contracts inherited from the past; indeed, in the majority of the cases, they were originally designed for monopolistic industries as, at the time, monopoly was the most diffused market structure. In these arrangements, the obligations for the high season, during which nowadays entry occurs, are calibrated much like those for the low season, when the presence of competitors remains still unlikely. The observation we have just made suggests that a regulator who neglects to incorporate the implications of the market forces at work, while determining bounds for prices and frequencies, should preferably have a utilitarian attitude and attribute unitary weight to the surplus of any category of economic agents; indeed having $\omega^{s,i} = 1$ also for $i = r$ would compensate, to some extent, for the distortion otherwise induced.

6 Conclusions

Domestic ferry industries provide maritime transportation services between islands and continental territories. In several such European sectors, ongoing contracts with traditional monopolies are approaching expiration, some publicly-owned companies are getting close to privatization and new suppliers have started operating. Though the specialized literature has devoted close attention to the design of appropriate institutional frameworks for other transportation sectors, it has not for the ferry service. The present paper has attempted to deal with this issue, which is especially relevant in the evolving European environment.

Hinging on many examples observable in the EU, we have stylized a formerly monopolistic industry, where the incumbent (eventually) competes as a Stackelberg leader with an entrant/follower *vis-à-vis* a heterogeneous population of passengers, whose behaviour is dictated by a pair of individual parameters (the taste for the service and the disutility of waiting time). We have highlighted the trade-off arising from the circumstance that prices differentiate per market segment and season, while frequencies solely adjust per season. We have shown that the exercise of market power by the strategic operators makes the free market equilibrium hardly satisfactory from a social viewpoint. Stemming from this result, we have deduced that regulation is needed to ensure the provision of sufficient and affordable connections, in observation of the territorial continuity principle. Therefore, it is not advisable that, after the expiration of the contracts and obligations still in force, any institutional constraint is ruled out and the market forces are let operate uncontrolled.

Nowadays, the design of the appropriate regulatory policy for the maritime ferry services constitutes a difficult task, as it pursues two different objectives: firstly, on an efficiency ground, new operators should be encouraged to enter the industry and the potential advantages of competition made available; secondly, on a distributional perspective, specific tutelage has to be devoted to the categories of travellers that are particularly penalized by the drawbacks of insularity.

We have coped with this issue by exploring a regime of partial regulation under complete information, in which the residents are especially favoured; compatibly with the EU prescriptions, we have envisaged a scenario where the incumbent is compelled to meet social service obligations in terms of tariffs and frequencies, whereas the entrant operates unregulated. We have demonstrated that cross-subsidization across categories of passengers is a crucial component of the pricing policy; additionally, in a market characterized by significant seasonality, this practice may contribute to smooth the scheduling path all over the year. We have as well shown that, when the unregulated competitor is active, the incumbent can be bound to milder duties, hence more easily cover its costs of operation.

A contract specifying (upper bounds for) the prices and (floors for) the frequencies of the regulated firm would implement the optimal partial regulation policy under quite strict conditions. Arrangements exhibiting similar characteristics were typically signed years ago with monopolistic providers and remain still now in force under the 1997 EC Guidelines [12]. As conceived for monopolies, they neither account for nor promote access by competitors. Hence, they suit the actual state of the ferry industry, at best, during the low season, when no entry usually occurs, but they are hardly well posed for the high season, when competition is likely to appear. This suggests that, in the majority of the cases, it would not be opportune to simply renew the existing contracts, as they should rather be revised compatibly with the evolution of the sector.

Finally, we would like to remark that the whole analysis has been performed and the conclusions drawn under the (implicit) assumption that shippers charge linear prices. Nevertheless, in real-world ferry industries, frequent customers (in general, the residents) are usually offered the possibility of benefiting from quantity discounts, so that the unit price decreases as the number of purchased tickets gets larger. Formally speaking, this circumstance might be represented by allowing operators to offer two-part tariffs. Intuitively, the adoption of a more sophisticated pricing instrument might induce a different allotment of passengers between providers. In particular, it would be interesting to explore which shipper (if any) would propose two-part tariffs, absent any regulatory constraint, as well as whether and under which circumstances two-part tariffs might replace the special weight we have attributed to the residents' surplus under the partial regulation regime. This is left to further research.

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