Asymmetric duopoly with a regulated upstream bottleneck.

An analysis on legal and ownership unbundling and vertical integration in the rail industry.

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Abstract

We assess the effect of legal unbundling, full separation and vertical integration in presence of a (partial) state-owned enterprise. This is particularly relevant in the rail industry characterized by an upstream bottleneck (Infrastructure Manager) and downstream competition (Rail operators), with the incumbent often under public ownership. We analyse first and second best policy. While we show that legal unbundling always maximizes total supply, we find that for low enough access charges, full separation is preferred to vertical integration whilst the converse happens for access charge higher than a certain threshold. Additionally, the presence of state's stake increases the presence of anti-discriminatory behaviours when the incumbent is more efficient than the rival.

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1 Introduction

The aim of this study is to apply recent developments in the regulatory literature to the rail industry characterized by vertical relations in presence of a regulated upstream bottleneck (Infrastructure Manager) and downstream competition in regime of open access in order to identify the first and second best network structure yielding the highest number of passenger services in the economy. This is coherent with the goals of the EU White Paper (EU 2011[1]), for which Governments are expected to sustain a modal shift to rail of the greatest majority of the medium distance intercity passengers and freight journeys by 2050 with the purpose to stimulate a competitive and environmentally friendly transport system. In looking at network structures ensuring the greatest number of services, we follow and extend the work of Hoffler and Kranz (2011a).

The European rail industry has experienced radical changes in the passenger segment since 2001 with the First Railway Package in the attempt to harmonize different practices[2] and to allow in-market (open access) and for-the-market (franchise) competition among different operators. The openness to the market has been accompanied with the enforcement of the separation of interests of the former vertically integrated incumbent through forms of legal and ownership unbundling. Legal unbundling is a mild form of vertical integration consisting in a formal separation of the downstream and upstream subsidiaries within an holding group while ownership unbundling represents a form of full separation no longer involving vertical relationships. To strengthen the independence of the Infrastructure Manager operating at the upstream level, the European Commission has recently proposed a Fourth Railway Package[3] to "remove risks of conflicts of interest and possible distortion of competition" (UE-COM 2013 p. 5) although allowing for "existing holding structure with infrastructure manager's ownership" under conditions of "strict safeguards to protect the independence of the infrastructure manager" (UE-COM 2013 p. 6)[4].

We focus on rail networks since, differently from other sectors experiencing similar vertical relations, this is characterized by the presence of historical public incumbents in the greatest majority of European countries (see Casullo 2016) which is likely to affect the outcome of the competition. One could imagine that public enterprises are less willing to raise rival's costs since aiming to supply services for citizens and take care of the welfare, without harming a fair competition. However, as shown by Sappington and Sidak (2003; 2004) and confirmed also by our results, the fact that public enterprises have objective functions different from only profits makes them more likely to pursue aggressive anti-competitive policies. This fits the case of

[1] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0144&from=EN

[2] According to Bergantino (2015) "the separation obligation between the infrastructure manager and railway undertakings [..] interpreted differently, resulting in a host of alternatives ranging from *full institutional separation* to *vertically integrated holdings*" (p. 173). Sweden opted for full separation in presence of public ownership (see Anderson and Rigas (2013), the UK for ownership separation with franchising while Austria, Germany (see Link 2012) and Italy on network structures which are also in the plan of France (Mizutani et al. 2015).

[3] A summary of the progressive legislation developed at the European level can be found at this link: http://ec.europa.eu/transport/modes/rail/packages/2001_en.htm

[4] Avoiding market distortions and abuses assumes particular relevance for making effective the development of open access in European Countries. As the Italian experience confirms, the *open access* policy resulted in increases in the supply of services and greater benefits for consumers. Bergantino et al. (2015) show that the entry of the private operator led to a greater utilization of the network, with the incumbent reacting by increasing its supply rather than by cutting it for the tougher competition. They also find that prices for the incumbent (Trenitalia) are 30-35% higher than those charged by entrant (NTV). Cascetta and Coppola (2014) verify how the presence of on-track competition led to a reduction on the average ticket price of around 31%. Alvarez-SanJaime et al. (2015) studying infra and inter modal competition verify how forms of privatization of HSR lead to reduction in the consumer surplus caused by increases in prices and reduction in frequencies but the entry of a new private operator can mitigate the negative effect thanks to more intense competition. Tomeš et al. (2014; 2015) summarize the results of the open access policy in the Czech Republic on the Prague-Ostrava segment characterized by a triopoly and intense competition. While they find that consumers enjoyed price reductions and quality improvements, all the three operators experienced negative profits. This result is also explained by the authors by the absence of industry-dedicated regulator able to avoid incumbent abuses.

the rail industry as there are cases reported to Antitrust authorities regarding the determination of the access charge as well as abuses in the allocation of slots and timing of departures (Agcm 2014; Bergantino et al. 2015)[5]. Differently, by looking at the nature of the ownership, also intermediate cases can be analysed as it could be the willingness of the Italian government to sell part of its shares and allow for partial privatization[6].

Our first research question is the same as in Hoffler and Kranz (2011a), that is to investigate the best network setting. However, by relying on precise function forms and having in mind the rail industry, we look also at second-best alternatives and the related policy implications to pursue when the first best alternative is not feasible because of failure in separating interests, ineffective Antitrust authorities or corruption. As an example, Van Koten and Ortmann (2008) discuss how different regimes coexist within the European Union with different degree of unbundling ranging from more severe unbundling (vertical separation) to the weakest form involving only accounting separation. They find that countries with high index of corruption are associated with weaker regimes of unbundling in utility markets.

To evaluate the second best network structure, we look at the access charge cut-off. This gives insights on the maximum or minimum level of the access charge that should be determined by the regulator to maximize total quantity in the economy given the *politically* preferred network structure[7]. We find that legal unbundling is the best form for maximizing quantity in the economy by sharing the benefits of greater coordination within the holding, which solves the problem of double marginalization (Splenger 1950) and ensuring a fair competition in the downstream market not affected by discriminatory practices. However, when this is not feasible, the analysis of the second best environment shows that when the public incumbent is more efficient than the fully separated private rival, public ownership is detrimental to the competition since it increases discriminatory behaviours. In this case, ownership separation can help to avoid anti-competitive practices but can be preferred if and only if the regulator commit to maintain low enough access charge. In contrast, access charges need to be set high enough when vertical integration is preferred. However, when the public incumbent is not too efficient with respect to the rival and discriminatory activities are relatively expensive, then vertical integration and legal unbundling are equivalent, fair competition is restored and the economy benefits from both downstream expansion of the rival and absence of double marginalization.

To model public ownership we follow the seminal works of Sappington and Sidak (2003; 2004)[8] on Managerially Oriented Public Enterprises. In this sense, we depart from the classical literature on Mixed Duopoly (see the seminal works of De Fraja and Delbono (1989)) often used in transportation economics for studying the behaviour of rail operators when competing against fully private airlines[9]. This makes also easier to consider our analysis according to the extent of the state's stake in the incumbent ownership and

[5] These abuses were not new to the Italian Competition Authority (Agcm), as it was the case of other forms of discrimination operated by the Italian incumbent to push the private operator Arenaways out of the market (EU-COM 2013; See also the decision of the Italian Competition Authority (Agcm) in August 2012 http://www.agcm.it/component/joomdoc/allegati-news/A436_chiusura.pdf/download.html . Conflict of interests of the incumbent, thus, could have deterred entry in other countries where, as shown by Casullo (2016), open access is implemented *de jure* but not *de facto* (e.g. Lithuania, Poland, etc.). According to Gómez-Ibáñez (2016), also the thin margin of profitability played a role.

[6] FSI is the Italian state-owned holding group acting as monopolist in the upstream market (Network Provider) and operator in the downstream market through the affiliate Trenitalia and competing against the fully private entrant operator NTV Italo. Before 2012, the entry of NTV, Trenitalia was the only operator within the market acting as a monopoly. Recently the Italian government was thinking to privatize 40% of the FSI. See http://www.governo.it/articolo/comunicato-stampa-del-consiglio-dei-ministri-n94/3255 .

[7] This is, as an example, what happened in Italy where the Antitrust Authority (Agcm) decided to lower the access charge in the railway industry where NTV and Trenitalia operates in regime of open access. The access fee is composed by a fixed amount per route plus electricity costs and a charge per km per each link. This was around 12,8 euro in 2014 and reduced to 8,2 euro for 2015 as a consequence of the Italian Competition Authority decision.

[8] See also Capobianco and Christiansen (2011).

[9] Yang and Zhang (2012) analyse the case where the High Speed Rail competes against private airlines by maximizing a weighted sum of consumer and profit surplus. Alvarez-SanJaime et al. (2015) consider a mixed duopoly where the rail operator maximizes own profits, profits of airlines and consumer surplus subject to the non-negativity constraint of own profits.

to evaluate potential scenarios in case of partial privatization of the Italian holding group. By focusing on MPE (or also SOE, State-owned enterprise, henceforth), we are able to capture the fact that state-owned enterprises take care not only of profits but also on revenues, that is - to a certain extent - to the demand side aspects. In other words, this translates to the fact that operating costs (and access charges) are discounted according to the share owned by the Government and, when a duopoly exists, the SOE will raise the cost of the rival and this is increasing in the state stake, that is the less profit-oriented the firm is. This approach has been recently used by Cambini and Spiegel (2016) to analyse investment decisions and capital structures in a framework with partial privatization but we are not aware on studies concerning different vertical structures as we do in this work.

Our paper stands close to the strands of literature concerned with Antitrust issues and sabotage effects by focusing our attention to cost-increasing sabotage aimed to raise rival's operating costs. Coherently, with the relevant literature (Sibley and Weisman 1998; Mandy 2000), we find that under Cournot competition, sabotage arises depending on the structure of downstream competitors and on the extent of the competitive advantage of the SOE incumbent over the rival. Raising rival's marginal cost can lead to reduction in the supply of the rival and, thus, damaging upstream revenues and this happens mainly if the vertically affiliate is less efficient. However, we find that when the rival firm is more efficient than a vertically integrated SOE or the latter is only slightly more efficient, than it becomes optimal to provide negative sabotage, that is a sort of subsidy. This is justified by the fact that upstream revenues becomes more relevant than those coming from the downstream market as a consequence of the higher efficiency of the rival, where efficiency is considered by taking into account both quality and operating costs.

The remainder of the paper is as follows. Section 2 provides insights on previous analysis. Section 3 presents the elements of the model and the different settings. In Section 4 we discuss our main results while Section 5 extends the baseline model to the Cournot-Stackelberg competition. Section 6 concludes the paper.

2 Related Literature

Previous works on network structures, instead, have mainly considered the case of broadband regulation (Avenali et al. 2010; Avenali et al. 2014) or telecommunication, energy (Pollitt 2008) and gas. Only few papers have been previously concerned about whether to integrate or separate downstream and upstream markets. Regarding the rail industry Ksoll (2004) provides a summary of the advantages arising from integration as coordination and conflict settlement, investment incentives, higher productivity levels, cost savings driven by shared facilities, technological and product innovation, limitation of the excessive entry.

More recently, empirical analysis have been concerned with efficiency aspects of different rail network structures. Mizutani and Urashini (2013) analyse full separation and full integration models finding that both can be preferred but according to different traffic density, Mizutani et al. (2015) extend the work by investigating a broad range of company models and including also the case of holding company (legal separation). They find that legal unbundling leads to smaller and slightly significant cost-reduction with respect to model with full integration. Conversely, they find that vertical separation may be costly when the train density is higher than a certain threshold and this is justified by the authors in terms of coordination problems.

Theoretical works, instead, have been more general in their applications. By considering network structures, Hoffler and Kranz (2011a) define as *legal unbundling* the case of the upstream monopolist maximizing only its own profits and the downstream firms maximizing both. This differs from the case of *reverse le-*

gal unbundling[10] also evaluated in their analysis and defined by the downstream firm maximizing its own profits and the upstream firm the joint profits of the network. They find that, as long as the access price is regulated and not endogenously chosen by the network company, this configuration can be beneficial for the total quantity provided in the market. The authors argue also that under legal unbundling total quantity is at least higher as in the case of ownership separation representing, thus, a *golden mean*.

In a complementary paper (Hoffler and Kranz 2011b), they explore the *imperfect unbundling* by considering an exogenously regulated access price paid by all competitors in the downstream market and with a upstream firm not fully separated in its interest and being *biased* in favour of its subsidiary in the downstream market. They conclude that an increase in the degree of integration between the downstream and upstream firm determines positive effects as long as the bias of the upstream firm is small. They also add that full separation is not optimal but there is a degree of optimal ownership share.

Cremer and De Donder (2013) study ownership separation and reverse legal unbundling (or functional separation, using the words of Avenali et al. (2014)) in absence of sabotage behaviours by considering a long-run perspective and investment in the network. They show that full control of the downstream subsidiary is welfare-enhancing for both downstream operators since both benefit from investments made by the upstream affiliate. Bolle and Breitmoser (2006) state that legal unbundling implies reduced prices than in presence of full separation but this depends on the effectiveness of the regulatory regime, on the extent of the downstream competition and on the difference between access charge and upstream operating costs. Therefore, the more competitive the market is, the smaller is the difference between legal and ownership unbundling. Matsushima and Mizutani (2014) consider a simple model with three players (train company, rail infrastructure company and labour union) and demonstrate that vertical integration is optimal provided that the market size is high enough and the effort cost is small. However, their analysis considers only the monopoly without providing a comparison among different market structures.

Vertical relations have been extensively analysed for the risk of discriminatory behaviours. This is relevant since, when the same holding group is active both at the upstream level, where there is a bottleneck, and in the downstream market, then there might be moral hazard for altering the competition and determining *abuse of dominant position* or *margin squeezing* behaviour[11]. According to Laffont and Tirole (1994 p. 1674), "is too easy for the monopoly in charge of the network to provide unfair advantages to its own products (favorable access charges, superior quality of access, R&D subsidies...) even if subsidiaries are created to improve cost auditing".

As described by Beard et al. (2001), "sabotage occurs when the upstream dominant firm artificially increases the unit costs of unintegrated downstream rivals by degrading input quality or imposing other cost-increasing, non price terms of sale" (p. 327). The effect of cost-increasing sabotage actions is strictly related to how these are modelled. When the cost is not high, only corner solutions (no sabotage at all or foreclosure) are feasible (Economides 1998; Mandy 2000) unless products are fully differentiated (Mandy and Sappington 2007)[12].

[10]This case is also analysed by Cremer and De Donder (2013) and by Avenali et al. (2014).

[11]According to Vickers (2005 pp. F250-F251) "A margin squeeze occurs when a vertically integrated dominant firm sets the wholesale price for an upstream product, upon which downstream rivals rely, and the retail price for its final product such that the margin between them is unduly low, thereby anti-competitively squeezing rivals downstream [...]. Equivalently, a margin squeeze occurs when the wholesale price is unduly high relative to the retail price – a kind of raising rivals costs [..]".

[12]In a recent paper, Mandy et al. (2016) consider a model with more players in the downstream market showing that the vertically integrated provider tends to target its anti-competitive behaviours against its direct and more aggressive competitor. They show that under quantity competition a vertically integrated firm chooses to sabotage the Stackelberg leader (while under price competition, sabotage is targeted against the other follower) when acting as a follower and to its closest follower when acting as a leader (as it happens under Bertrand competition).

However, there are also other forms of discrimination arising as those directed to reduce the demand of the rival firm. As an example, Mandy and Sappington (2007) model the upstream network provider as supplying access to the infrastructure and involved in either cost-increasing and demand-reducing sabotage or both. They show that under Bertrand competition, the upstream will always refrain from demand-reducing sabotage. Pal et al. (2012) study the inverse relationship between demand-reducing sabotage and investment in cost-reduction made by the rivals.

3 The model

Following Dixit(1979) and Singh and Vives (1984), we use a quadratic utility function for a representative consumers, which takes the following concave functional form

$$V(q_1, q_2, y) = \alpha_1 q_1 + \alpha_2 q_2 - \frac{1}{2}(b_1 q_1^2 + 2\gamma q_1 q_2 + b_2 q_2^2) + y \tag{1}$$

subject to the budget constraint $y = \sum_{i=1}^{2} p_i q_i$, where q_i is the amount of goods/services consumed by the operator i and p_i is the related price. For the sake of simplicity, we assume that the *own* marginal effect on the utility function as equal to $b_1 = b_2 = 1$ and as well as $\gamma = 1$. This means that we do not model the degree of substitutability among services whilst we focus more on fully competitive outcomes and we avoid monopolistic solutions. This makes, indeed, products homogeneous except for differences in the willingness to pay for each service arising from α_1 and α_2 so as to allow for product differentiation. In fact, although products are homogeneous, it is often the case that operators invest some resources for differentiating themselves by allowing for additional services as the presence of efficient wi-fi connections, comfortable seats, the quality of the food provided or the presence of fidelity cards. In this sense, also the willingness to pay for traveling with a precise operator may differ[13]. We also complement asymmetries in the quality perceived by the consumers by assuming the presence of different marginal costs for running the service. In this way, we are able to model both asymmetries in costs and quality, which are quite important for characterizing our first and second best solution.

The representative consumer maximizes his utility in Equation (1) with respect to q_1 and q_2. After manipulation, the inverse demand functions are

$$p_1 = \alpha_1 - q_1 - q_2 \qquad p_2 = \alpha_2 - q_2 - q_1 \tag{2}$$

We consider the following three cases, which are also summarized in Figure fig: market

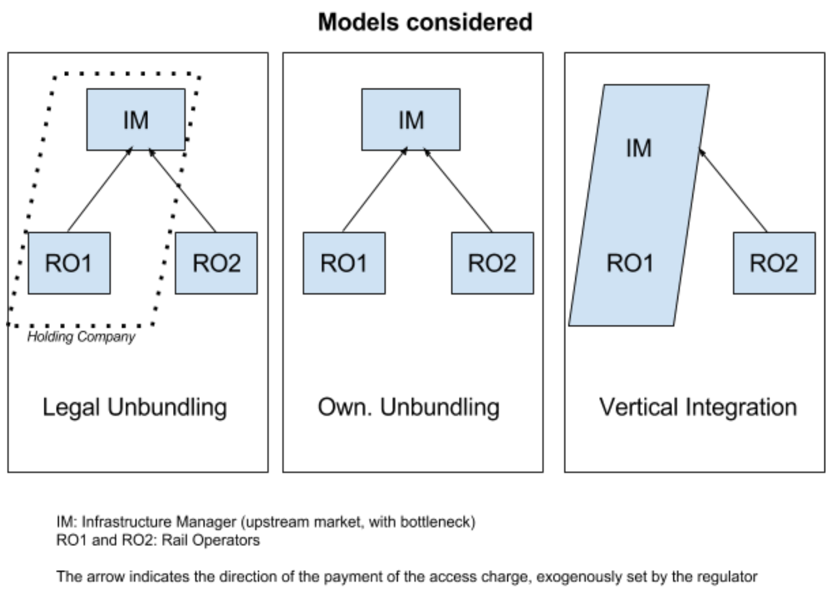
- *Legal Unbundling* (U), as defined in Hoffler and Kranz (2011a) with the upstream firm maximizing only own profits whilst the downstream firm joint profits. Legal Unbundling is said *perfect* when there are no sabotage activities.

- *Vertical Integration* (VI), with the joint maximization of the upstream and downstream profits in presence of optimal sabotage strategies. In this case the network group engages in strategic sabotage activities for increasing (reducing) the competitive advantage with respect to the rival.

[13] This happens mainly for the railway industry rather than in other sectors (e.g., energy, gas, etc.) characterized by the same upstream bottleneck and downstream competition

- *Ownership Unbundling* (C) or full Separation as simultaneous quantity competition where differences are only in efficiency and degree of substitutability. There is no discrimination or sabotage.

Figure 1: Summary of the Market structures



As we are interested in assessing different company configurations with the railway industry, a common assumption is that both firms compete in quantities. This is a standard assumption applied to works about inter modal competition (D'Alfonso et al. 2015) or cooperation (Pilar Socorro and Fernanda Viecens 2013; Jiang and Zhang 2014) although some studies focus mainly on pricing strategies (Yang and Zhang 2012). As reported by D'Alfonso et al. (2015) the main justification for considering a Cournot competition is found in the difficulties in adjusting high speed capacity, due to the presence of physical limitations. Prices, instead, usually represent short-term equilibrium as also reported by Bolle and Breitmoser (2006).

Thus, both firms maximize their output simultaneously in the baseline model choosing the optimal quantity supplied by working under fixed proportions. In Section 5 we consider sequential games. Following D'Alfonso et al. (2015), the quantity of goods provided by each firm is given by the number of connections (frequency) times the load factor and the size (number of seats). Assuming, for the sake of simplicity, that size and load factor are fixed and equal for both modes, then the quantity provided (seats) is a linear transformation of the number of daily connections.

Therefore, consider $\delta \in [0, 1]$ the share of the Government in the (partially) state-owned enterprise, which acts as incumbent, then the objective functions of the SOE (treated always as firm 1) is

$$\begin{aligned} \Pi^{SOE} = \Pi_1 &= \delta R + (1-\delta)(R - C) - IK[s] \\ &= R - (1-\delta)C_2 - IK[s] \\ &= R^U + R^D - (1-\delta)(q_1(c_1 + a)) - IK[s] \end{aligned} \tag{3}$$

where R represents the revenue from the upstream (when present, that is under vertical integration and legal unbundling) and downstream side, I is an indicator function taking value equal to 1 when sabotage s is considered and 0 otherwise, a identifies the access charge paid to the upstream monopoly (itself when within the same firm or holding), c_1 while K is the cost of sabotage depending on the per unit cost $\phi > 0$. We assume that $K(0) = 0$ and convex in its argument, thus non-decreasing in the amount of sabotage performed. For the sake of simplicity, we generalize to 0 upstream marginal cost to provide network access and we assume that there are no fixed and sunk costs.

From Eqn. 3, it is important to see how the most operating costs and access charge are discounted the greater is the share of the state in the enterprise. When the SOE is fully public ($\delta = 1$), then operating costs are not considered at all giving raise to double gains: i) access charge paid to itself is only considered as revenue but not as a cost; ii) operating costs are not relevant at all. Likewise, when $\delta = 0$, then the analysis shrinks to a simple duopoly model with only profit-maximizing firms.

We rely on costly sabotage and we model it as quadratic, that is with increasing returns and defined as follows

$$K[s] = \phi \frac{s^2}{2} \tag{4}$$

where from $\phi = 0$ sabotage costs are absent.

Moreover, we define the objective function of the rival and fully separated firm as

$$\Pi_2 = (p_2 - Is - a - c_2)q_2 \tag{5}$$

where p_2 charged by the firm, a identifies the access charge paid to the upstream bottleneck, s the cost-increasing sabotage while c_2 the operating cost. As shown sabotage enters negatively in the profit function of the rival firm but this happens only when $I = 1$, that is when the indicator function is switched on.

The set-up is as follows:

- 1. The Government chooses the best network structure (first and second best);
- 2. If vertical relations are present, the SOE incumbent defines its sabotage strategy;
- 3. Both firms compete in quantity

We solve the game backward. It is straightforward to verify how the second stage is not considered in presence of ownership unbundling since no sabotage and no vertical relationship are present. We do not model endogenously the optimal access charge since we think this can represent a short-run decision. It is important instead define the conditions under which each network structure can be preferred and adjust access charge satisfying them.

3.1 Legal Unbundling and Vertical Integration

The set-up for the legal unbundling and vertical integration case is the same in the third stage. They differ with respect to the second stage where the vertically integrated firm decides the sabotage strategy to maximize the joint profits of both sides of the market while under legal unbundling this is a decision only of the upstream affiliate. Therefore, let us define the objective function of the SOE incumbent as follows

$$\begin{aligned} \Pi_1 &= R^U + R^D - (1-\delta)(q_1(c_1 + a)) - K[s] \\ &= a(q_1 + q_2) + q_1 p_1 - (1-\delta)(q_1(c_1 + a)) - K[s] \\ &= a(q_1 + q_2) + q_1(\alpha_1 - q_1 - q_2) - (1-\delta)(q_1(c_1 + a)) - \phi \frac{s^2}{2} \end{aligned} \tag{6}$$

which is well-behaved in q_1. By allowing for the Cournot competition, the SOE maximizes its objective function by choosing quantity q_1. Indeed, from first order conditions

$$\frac{\partial \Pi_1}{\partial q_1} : 0 = (c_1 + a)\delta - c_1 - 2\,q_1 - q_2 + \alpha_1 \tag{7}$$

Simultaneously, the rival maximizes Eqn. 4, that is only its profit function

$$\frac{\partial \Pi_2}{\partial q_2} : 0 = -2\,q_2 + \alpha_2 - s - q_1 - c_2 - a \tag{8}$$

Solving for the Cournot-Nash Equilibrium, in the third stage we obtain

$$q_1(s) = \frac{1}{3}(a(2\delta + 1) + s - 2c_1(1 - \delta) + c_2 + 2\alpha_1 - \alpha_2) \tag{9}$$

$$q_2(s) = \frac{1}{3}(2\alpha_2 - \alpha_1 + c_1 - 2c_2 - 2s - \delta(a + c_1)) \tag{10}$$

yielding

$$\begin{aligned} Q(s) &= q_1(s) + q_2(s) \\ &= \frac{1}{3}(\alpha_2 + \alpha_1 - c_1(1 - \delta) - c_2 - s - a(1 - \delta)) \end{aligned} \tag{11}$$

From these equations, it is interesting to see the effect of a marginal increase in the access charge. In particular,

$$\frac{\partial q_1}{\partial a} = \frac{1}{3}(2\delta + 1) > 0 \qquad \frac{\partial q_2}{\partial a} = -\frac{1}{3}(\delta + 2) < 0 \qquad \frac{\partial Q}{\partial a} = \frac{1}{3}(\delta - 1) \leq 0 \tag{12}$$

which means that increasing access charge determines a shift in the production from the rival to the SOE with a negative total effect on total quantity of $\delta \neq 1$. Instead, when SOE is totally public ($\delta = 1$), an increase in the access charge does not determine any effect on total quantity. This is justified by the fact that the SOE discounts the access charge, which means that becomes less relevant.

3.1.1 Legal Unbundling

Plugging optimal quantity in the upstream affiliate profit function when there is unbundling $R^U = a(q_1 + q_2) - \phi\frac{s^2}{2}$, then we obtain the following reduced form function

$$R_1^U(s) = \frac{1}{3}(c_1(\delta - 1) - c_2 - s + \alpha_1 + \alpha_2)a - \frac{1-\delta}{3}a^2 - \frac{\phi s^2}{2} \tag{13}$$

It is easy to see that $R_1^U(s)$ is not convex in s but the upstream will refrain from anti-competitive behaviours since optimality would require negative optimal sabotage, that is a sort of subsidization. Therefore, under legal unbundling $s = 0$ and total quantity in the economy is equal to

$$Q^U = \frac{1}{3}(\alpha_2 + \alpha_1 - c_1(1 - \delta) - c_2 - a(1 - \delta)) \tag{14}$$

Thus, as in Hoffler and Kranz (2011a), legal unbundling works perfectly in separating the interest of both sides of the holding company and the upstream subsidiary will refrain from sabotage when maximizing own profits. The result would differ, instead, under the case of *functional separation* or *reverse legal unbundling* where the upstream maximizes joint profits and downstream firm. In this case, since the upstream operator would care also about the downstream affiliate profits, then sabotage could still arise but depending on the extent of the competition in the downstream market and on the competitive gap among operators.

3.1.2 Vertical Integration

Moving to the case of vertical integration, we plug optimal quantities into Eqn. 6, which gives the following expression reduced form objective function

$$\begin{aligned}\Pi_1^V = &\frac{1}{9}(4(c_1+a)^2\delta^2 + (c_1+a)(a+4(s-2c_1+c_2+2\alpha_1-\alpha_2))\delta + 4c_1^2) \\ &+\frac{1}{9}((4(\alpha_2-c_2-s-2\alpha_1)-a)c_1 - 5a^2 + (\alpha_1+4(\alpha_2-c_2-s))a) \\ &+\frac{1}{9}(\frac{1}{2}(-9\phi+2))s^2 + 2(c_2+2\alpha_1-\alpha_2))s + (c_2+2\alpha_1-\alpha_2)^2)\end{aligned} \tag{15}$$

Lemma 1. *Absent sabotage costs or being these small enough such that $\phi < \frac{2}{9}$, the vertically integrated incumbent will either refrain from sabotage or provide foreclosure.*

From Lemma 1, we find this is a common result in the literature (Economides 1998;Mandy 2000; Hoffler and Kranz 2011b; Mandy et al. 2016). When discriminatory behaviours are not associated with fines, sanctions or costs or these are very small, then the vertically integrated firm's profits are convex in sabotage such that $\frac{\partial^2 \Pi_1^V}{\partial^2 s} > 0$ and it will either refrain from sabotage or drive the rival out of the market.

However, in our case, we are mainly interested in assessing non-detrimental sabotage behaviours, that is discriminatory behaviours that raise rival's marginal cost but without providing foreclosure. To avoid this case, we need to assume that $K(.)$ is sufficiently convex and sabotage costs rapidly increase by making the following assumption

Assumption 1. *Sabotage costs are not small enough, that is $\phi > \frac{2}{9}$.*

which ensures, indeed, that the profit function is well-behaved and concave in s. Thus, as far as Assumption 1 holds, then the vertically integrated firm chooses the optimal sabotage s by maximizing Eqn. 15.

Definition: Call $\xi = 2(\alpha_1 - c_1(1-\delta)) - \alpha_2 + c_2$ the efficiency gap among the players, which is positive when the incumbent SOE is more efficient than the rival and negative when the converse holds.

We consider two cases which gives us the idea of the difference in efficiency among firms. In the first case, we consider the SOE firm more efficient than the rival such that $\xi > 0$ and the efficiency gap is increasing in the level of public shares, that is in the extent of the discount of operating costs. This means that when the degree of state ownership increases, then the more efficient SOE increases its competitive advantage over the rival by caring less at its costs and more at revenues and demand aspects. In the second case, we consider a different scenario where the SOE is less efficient than the private rival such that $\xi < 0$ and decreasing in δ. To sum up, as measure of efficiency we consider the difference in quality, captured by the parameters α_i and marginal costs c_i with $i: 1, 2$. Indeed, the efficiency gap can be thought as that described by Zanchettin (2006) despite differences arising from discounting.

Given these premises and taking first order conditions with respect to s and rearranging we obtain

$$\begin{aligned} s^{V*} &= \frac{2}{9\phi-2}(2\alpha_1-\alpha_2+c_2-2c_1(1-\delta)-2a(1-\delta)) \\ &= \frac{2}{9\phi-2}(\xi-2a(1-\delta)) \end{aligned} \tag{16}$$

whose sign is ambiguous and strictly depend on the numerator as long as the denominator is positive by Assumption 1($\phi \geq \frac{2}{9}$).

By focusing on sabotage, that is anticompetitive behaviours taken by the SOE against the rival in the downstream market, we restrict the analysis only on positive sabotage. If the optimal sabotage is negative, then the vertically integrated provider will refrain from sabotage. Then, two cases arise according to the efficiency gap:

- *Case 1.* If the SOE is *absolutely* more efficient than the rival such that $\alpha_2 - c_2 + 2a(1-\delta) \leq 2(\alpha_1 - c_1(\delta-1)) \rightarrow \xi \geq 2a(1-\delta)$. This means that, regardless the level of the access charge a and the share of public ownership δ, when the incumbent is less efficient than the rival, then optimal sabotage is positive and identified by Eqn. 16. This automatically implies that when the SOE is fully public ($\delta = 1$), then $\xi \geq 0$.
- *Case 2.* If the SOE is *slightly* more efficient than the rival but not enough, that is $0 < \xi \leq 2a(1-\delta)$ for $\delta < 1$, then Eqn. 16 is negative and the SOE refrains from sabotage.
- *Case 3.* If the SOE is less efficient than the rival such that $\xi < 0$, then the SOE refrains from anti-competitive behaviour otherwise optimal sabotage would take the form of subsidy.

Proposition 1. *a) The vertically integrated SOE will raise rival's costs if and only if absolutely more efficient than the rival (Case 1).*
b) The extent of the sabotage effort is increasing in the state ownership.
c) In all other cases (2-3), the SOE will not discriminate the rival.

The proof of Proposition 1 (a) is trivial since coherent with what previously stated respect to Case 1. This result is close to Mandy (2000) and Economides (1998) and captures the idea that upstream profits can be harmed by the reduced demand when an efficient rival is forced to lower production as a consequence of increasing operating costs and the affiliate downstream profits do not exceed upstream losses. What is interesting, however, is that sabotage arises only when the competitive advantage is sufficiently large. It is not sufficient, indeed, to have $\xi > 0$ but ξ needs also to compensate damages at the upstream level, explaining why Case 1 differs from Case 2. Thus, if it is not the case and the competitive advantage is limited, then the vertically integrated firm will not harm competition and behave as in the case of legal unbundling (Proposition 1 (c)) as described by Eqn. 14. However, this represents a sub-optimal choice since, in this case, the vertically integrated firm will maximize its own payoff by subsidizing the rival. This would happen since, given the relative efficiency of the rival, upstream revenues would exceed downstream losses. Then, in equilibrium, under Case 2-3, the optimal sabotage would be negative taking the form of subsidy. However, this seems unrealistic in a real-world economy and we simplify consider that sabotage is nil.

As to Proposition 1 (b), the proof is a simple comparative statics.

$$\frac{\partial s^V}{\partial \delta} = \frac{4(a+c_1)}{9\phi-2} > 0 \tag{17}$$

An increase in the state's share δ makes the incumbent to discount more its cost allowing savings in terms of resources to be dedicated in anti-competitive behaviours and make the SOE to gain additional margins over the rival. This is coherent with Sappington and Sidak (2003) who found that having an objective function less concerned about profits and more on other factors, as demand or revenues, increases the probability of anti-competitive behaviours. ■

Therefore, using the optimal sabotage, we can derive total quantity under vertical integration

$$
\begin{aligned}
Q^V = & \frac{6}{9\phi - 2}((\delta(a + c_1) - (a + c_1 + c_2) + (\alpha_1 + \alpha_2))\phi) \\
& + \frac{4}{9\phi - 2}(a(1 - \delta + c_1(1 - \delta) - \alpha_1)
\end{aligned}
\tag{18}
$$

3.2 Ownership Unbundling

Next, we consider also the case of ownership separation in presence of SOE. No vertical relations are now considered and downstream fringes are fully independent from the upstream firm, namely the Infrastructure Manager. The objective function of the incumbent is that in Eqn. 3 with $I = 0$, that is

$$
\begin{aligned}
\Pi^{SOE} = \Pi_1^C &= \delta R + (1 - \delta)(R - C) - IK[\phi s] \\
&= R^D - (1 - \delta)C_1 \\
&= R^D - (1 - \delta)(q_1(c_1 + a))
\end{aligned}
\tag{19}
$$

where R^D refers to downstream revenues. Also in this case access charge and operating costs are discounted. By choosing quantity, we obtain the following f.o.c.

$$
\frac{\partial \Pi_1^C}{\partial q_1} : 0 = (c_1 + a)\,\delta - a - c_1 - 2\,q_1 - q_2 + \alpha_1 \tag{20}
$$

while the best response of the fully private firm is the same as in Eqn. 8 with $s = 0$ since no anti-competitive behaviour is allowed. By solving for Cournot-Nash equilibrium in the third stage, we obtain the following quantities:

$$
q_1^C = \frac{1}{3}(a(2\delta + 1) - 2c_1(1 - \delta) + c_2 + 2\alpha_1 - \alpha_2) \tag{21}
$$

$$
q_2^C = \frac{1}{3}(2\alpha_2 - \alpha_1 + c_1 - 2c_2 - \delta(a + c_1)) \tag{22}
$$

yielding

$$
\begin{aligned}
Q^C &= q_1^C + q_2^C \\
&= \frac{1}{3}(\alpha_2 + \alpha_1 - c_1(1 - \delta) - c_2 - a(2 - \delta))
\end{aligned}
\tag{23}
$$

Second stage is not present given the absence of sabotage. Next we move to the first stage of the game where the Government evaluates first and second best policy to maximize the total number of services in the economy.

4 Results

4.1 First Best Environment

Let us compare first the case of perfect legal unbundling with the two alternatives. According to Hoffler and Kranz (2011) legal unbundling provides a golden mean in terms of quantity in the economy resulting weakly better than vertical integration and ownership separation. In particular, vertical integration represents the worst scenario of the legal unbundling characterized by the maximum amount of sabotage. However, as shown in previous equations, when unbundling is perfect, the upstream affiliate will refrain from investing in sabotage activities since this would harm own profits and this is given by the fact that anti-competitive measures are costly or can be costly when detected by Antitrust authorities.

Lemma 2. *Suppose legal unbundling is perfect, such that no sabotage activity is involved, while this is optimal under vertical integration, then legal unbundling always produces greater quantities.*

The proof is simple. By comparing Eqn. 18 and 14 and define $\triangle Q^{UV} = Q^U - Q^V$, then this is equal to

$$\triangle Q^{UV} = \frac{1}{3}s > 0 \tag{24}$$

■

Lemma 2 highlights the benefits of legal separation where upstream decisions are completely independent on the extent of the downstream competition. This immediately translates in savings and, consequently, in additional quantities provided in absence of discrimination against the rival and making the competitive aspects in the downstream market to emerge.

Lemma 3. *Suppose legal unbundling is perfect and the alternative is ownership unbundling, then legal unbundling is preferred.*

The proof is rather simple also in this case. By comparing Eqn. 23 and 14 and define $\triangle Q^{UC} = Q^U - Q^C$, then this is equal to

$$\triangle Q^{UC} = \frac{1}{3}a > 0 \tag{25}$$

where the difference in only in the access charge. Obviously, for zero access charge, both network structures shrink to the same result. Indeed, perfect legal unbundling represents the first best. ■

Lemma 3 provides further motivation for preferring forms of legal unbundling over ownership separation. This can be related to the *downstream expansion effect* described by Hoffler and Kranz (2011a). Obviously, results from Lemma 4 strictly depend on the effectiveness of the Antitrust authority in ensuring that sabotage is heavily discouraged and in monitoring the separation of interest. Therefore, if this is the case, then legal separation should be preferred. On the other side, if the Antitrust authority is not effective, as it might be in countries characterized by widespread corruption, then lowering the access charge such that it tends to zero may reduce the gap with the first best solution.

But, does ownership separation really represent a solution in a second-best environment? For answering this question, we compare total quantity under vertical integration, representing the worst scenario when legal separation is totally ineffective, and ownership separation which eliminates any potential conflict of interest of the upstream network manager.

4.2 Second Best Environment

Proposition 2. *Suppose the rival in the downstream market is absolutely less efficient than the SOE incumbent (Case 1), then there exists a threshold for which ownership separation should be preferred to vertical integration:*
a) If the access charge is low enough, then ownership separation maximizes total quantity in the economy;
b) otherwise, vertical integration provides greater outcome for small enough access charge.

The proof is as follows. Consider Case 1 and define $\triangle Q^{CV} = Q^C - Q^V$, then using Eqns. 23 and 18 this gives raise to the following result

$$\triangle Q^{CV} = \frac{(4\delta - 9\phi - 2)a + 4c_1(\delta - 1) + 2c_2 + 2(\alpha_1 - \alpha_2)}{3(9\phi - 2)} \tag{26}$$

Since by Assumption 1 the denominator is positive this means that ownership unbundling should be preferred to vertical integration when the numerator is positive too, that is according to a different combination of parameters involving differences in efficiency (quality net of operating costs), access charge as well as the share of the government in the (partial) state-owned enterprise. Thus, isolating the numerator and solving for the access charge, we can disentangle optimal network structures in a second-best environment by looking at the cut-off point. Thus, when the rival is more efficient and sabotage is positive by Eqn. 16 (Case 1), then

$$\begin{aligned}
Q^C \geq Q^V \rightarrow (4\delta - 9\phi - 2)a + 4c_1(\delta - 1) + 2c_2 + 2(2\alpha_1 - \alpha_2) \geq 0 \\
(2 - 4\delta + 9\phi)a \leq 2(2\alpha_1 - \alpha_2) + 4c_1(\delta - 1) + 2c_2 \\
a \leq 2\frac{c_2 + (2\alpha_1 - \alpha_2) - 2c_1(1 - \delta)}{(2 - 4\delta + 9\phi)} \\
a \leq \frac{2\xi}{(2 - 4\delta + 9\phi)}
\end{aligned} \tag{27}$$

Thus, since $\xi > 0$ and by Assumption 1 the denominator is always positive, then the right hand side is positive too. This means that ownership unbundling represents a feasible second-best policy when the access charge is relatively low and, as we know from Lemma 2, the smaller is the access charge, the smaller is the gap with the first best (legal separation). In contrast, if the regulator wants to rely on vertical integration, this would represent a second best solution as long as the access charge is relatively high. This is quite intuitive since a vertically integrated firm ensures greater coordination between sides and solves the double marginalization problem. Therefore, this becomes a second best policy only when the access charge becomes high enough and solve efficiently the double marginalization problem arising from a greater access charge. However, this comes at the price of unfair competition since the more efficient and vertically integrated provider can damage further more the less efficient rival firm. Note, however, that this happens if and only if the vertically integrated SOE is absolutely more efficient than the rival since, in other cases, sabotage would not represent an issue since detrimental for upstream revenues.

The policy-related implication is that if the regulator is able to perfectly know the marginal costs for producing the input (access, which was generalized to 0 in our case) and sets the mark- up at very low-level or at 0, then full separation should be preferred as sub-optimal solution. Thus, when the Government prefers a more competitive network structure, the this goal should be reached by setting a very low access charge so as to stimulate entry and preventing from discriminatory behaviours when the vertically integrated SOE is absolutely more efficient than the rival. However, this comes at the price of raising upstream revenues to be invested in the network (improvements, extra-ordinary measures, etc) which may be funded directly by the government or using external resources (European Union, etc.)

Corollary 1. *Suppose the incumbent is fully private such that $\delta = 0$ and more efficient than the rival firm ($\xi > 0$), then the model is reduced to a asymmetric duopoly model with upstream bottleneck. Conclusion from Proposition 2 holds but the minimum threshold for the access charge is reduced.*

The proof is straightforward. Substitute $\delta = 0$ in Eqn. 27, then the denominator remains positive. Ownership separation needs very low access charge to be preferred. ■

Proposition 3. *Suppose the SOE is either more efficient but not too much (Case 2) or less efficient than the rival (Case 3), regardless the access charge and the share of the state in the economy, then the SOE will refrain from sabotage and vertical integration maximizes total quantity in the economy providing the same result as under legal unbundling (Lemma 3).*

Proposition 3 states that when the incumbent is slightly more efficient than the rival (Case 2) or when less efficient than the rival, then it will refrain from sabotage and make the vertical integration case as equal to that of legal unbundling. However, this is still sub-optimal since subsidization of the rival under vertical integration would have risen upstream profits and maximized the vertically integrated SOE profit function. In other words, despite the threat of sabotage arising under vertical integration, the SOE incumbent firm will never find profitable raising rival's cost when this more efficient to prevent damages in upstream profits. The absence of sabotage and the gains from greater coordination within the holding group (solution of the double marginalisation problem) explain why total quantities in the economy are greater under vertical integration. It is remarkable that, differently from the previous case, this solution is unique and not dependent on the relevance of the state in the economy.

Moreover, in this case differences are in the access charge and defining and access charge close to zero (or to marginal costs) would mitigate the problem of double marginalisation as explained by Hoffler and Kranz (2011a) but damaging the number of services offered.

Proposition 4. *Suppose Assumption 1 does not hold such that sabotage activities are more expensive, then convexity requirements are not satisfied. Then, if the duopoly exists, the vertically integrated SOE will refrain from sabotage maximize total quantity in the economy providing the same result as under legal unbundling (Lemma 2).*

Proposition 4 analyse the case arising in presence of convex sabotage costs. In this case, as shown by Lemma 1, the vertically integrated SOE will either avoid discrimination or provide foreclosure. This is justified by the fact that anti-competitive behaviours are so cheap or have zero-cost and, indeed, corner solution arises. However, by driving the rival out of the market, the vertically integrated firm makes transparent its actions and, thus, it may incur in charges not initially taken into account. Thus, when the duopoly exists, the SOE will refrain from sabotage fully separating the interest of the upstream bottleneck from that of the downstream affiliate.

5 Extension of the model

Cournot-Stackelberg model

We have previously considered simultaneous decisions of the incumbent and the rival in setting their quantity. However, how often is the case in the rail industry, decisions are sequentially, with a leader (incumbent) and a follower (entrant). For this reason, we study whether the same results apply in a Cournot-Stackelberg model.

Proposition 5. *Suppose the SOE is the incumbent acting as a quantity leader and the rival the entrant (follower), then*
a) the minimum sabotage cost avoiding convexity (corner solution) increases to $\phi > \frac{1}{4}$ *in Lemma 1;*
b) the sabotage level differs only in the denominator;
c) Proposition 1 and Lemma 2-3 remain unchanged;
d) Proposition 2 applies but the cut-off access charge is $\frac{2\xi}{(1-2\delta+4\phi)}$*;*
e) Corollary 1 and Proposition 3-4 remain unchanged.

Proposition 5 (a) states that the sabotage cost should be relatively less expensive than what previously found in Lemma 1 for ensuring concavity requirements and, indeed, avoid foreclosure. First, this means that the region in which the vertically integrated SOE leader can potentially drive out of the markets its rival decreases and this is explained by the greater advantage obtained by the leader in setting quantity first. Second, this can also mean that, if the duopoly exists under relatively costless discriminatory behaviours and foreclosure is prevented in some way, then the region in which sabotage is not considered decreases too confirming, thus, Proposition 5. However, it is important to point out that differences in the minimum sabotage cost ensuring concavity is meaningless, since by Lemma $\phi > \frac{2}{9} = 0.22$ while by Proposition 5 (a) $\phi > \frac{1}{4} = 0.20$. Then, foreclosure is avoided only slightly. However, this can have an impact on the extent of sabotage activities when these are present. By Proposition 5 (b) we know that, as compared to Eqn. 11, the only difference is in the denominator while the numerator is still the same.

By changing only the denominator of the sabotage effort, this automatically implies that the three cases arise according to the efficiency gap are confirmed also under Stackelberg competition and, indeed, sabotage will be undertaken if and only if the vertically integrated SOE is absolutely more efficient than the rival while will refrain from it in all other cases (Proposition 5 (c)). Additionally, as a consequence of slight changes in the sabotage level, the threshold of the access charge that allows to distinguish between the sub-optimality of vertical integration or ownership separation changes too. In particular, as shown by Proposition 5 (d), with a quantity-leader, ownership separation becomes optimal if and only if $a \leq \frac{2\xi}{(1-2\delta+4\phi)}$ where $\xi > 0$ in Case 1.

Proposition 5 (e) is straightforward as a consequence of previous points[14].

6 Conclusive remarks

This work analysise first and second best network structures under Cournot competition in presence of managerially oriented public enterprise. Coherently with the relevant literature we find that legal separation can represent a first best solution thanks to the presence of benefits characterizing both ownership separation

[14] A detailed proof is available upon request to the authors. This is not reported for the sake of brevity but follows the same passages as for the baseline model but in a Stackelberg style.

and vertical integration. In particular, a fair competition is ensured by the absence of anti-discriminatory behaviours and this is associated with the absence of transaction costs.

In the second best scenario, instead, the regulator should bear in mind that optimal network structures are strictly dependent on the determination of the access charge and, indeed, if ownership separation is implemented, the regulator should consider defining an access charge very low so as to stimulate competition. In contrast, a relatively high access charge becomes preferable under vertical integration because of the double marginalization.

However, this is true only when the SOE has a large competitive advantage. Likewise, we find that even vertical integration can represent a first best solution when the rival is more efficient (Case 3) or when the competitive advantage of the vertically integrated SOE is not high enough (Case 2). This is particularly important since by avoiding anti-competitive actions, vertical integration shrinks to the legal unbundling case. However, abstaining from sabotage under the last two cases is not an optimal choice since, as shown in the paper, optimality would require subsidization of the rival to boost upstream revenues at the expense of those in the downstream markets where services are offered to passengers a long as the first exceeds the second.

Particular interesting is what we find in the role played by public ownership, which matters in our analysis when sabotage is considered. In this case, public ownership is detrimental for competition since makes discrimination more likely. By interpreting our results in terms of the current Italian situation in the rail industry, we can state that the current system of legal unbundling in presence of full public ownership maximizes total quantity and avoids discriminatory issues as long as NTV, the entrant in the Italian downstream market is more efficient or slightly less efficient than Trenitalia, the current SOE incumbent. This ensures to avoid anti-competitive behaviours since the upstream affiliate of Trenitalia, Rete Ferroviaria Italiana, would gain more in terms of access charge from ensuring network access to the rival compared to downstream gains from the affiliate in the downstream market. In this circumstances, both vertical integration and legal unbundling are a first best solution and ownership unbundling is not optimal. In contrast, if Trenitalia is absolutely more efficient than NTV two cases arise according to the political view-point of the Government for maximizing quantities in the economy. If the Government wants to guarantee a fair competition and ensure ownership separation, then it should define an access charge close to marginal costs knowing that, however, funding to take care of the infrastructure should be found elsewhere. Likewise, vertical integration, which is no longer permitted but can be considered as the worst scenario under legal unbundling (totally imperfect) can ensure maximization of total quantities without driving the rival out of the market for high enough access charge. In both cases, however, public ownership is welfare-enhancing since it increases total quantity but, under vertical integration, it arises also the risk of discrimination.

Further, these results are robust also under Stackelberg competition where for costless discriminatory behaviours the quantity leader have a greater margin of sabotage to drive the rival out of the market with respect to the previous case. However, despite this condition, as shown in Proposition 5, all other results do not change.

However, these analysis have been carried out by considering an exogenously given access fee which is not influenced by the market structure. If the access charge was defined not by the regulator but one of the actor within the market, as a fully independent upstream firm, then the outcome would have been completely different. A natural extension of this framework would be to consider the propensity to increase network investments under SOEs for any vertical structures. This assumes particular relevance in the rail industries where upgrading the quality of the network to accommodate the increasing speed reached by rolling stock using new technologies. This would link our paper to the recent literature on investments (Cremer and De Donder 2013; Avenali et al. 2014).

We may speculate, for instance, that in our second best environment since, if the optimal access charge is non-discriminatory and setted as equal regardless the efficiency level of each firm, then ownership unbundling has to be preferred when the regulator goal is to keep the upstream monopoly mark-up very low such to compensate, for instance, the ordinary maintenance but leave investments and extra-ordinary expenditures to external sources (Government, European Union, etc.). This may be fit the case of the railway industry where the greater majority of Infrastructure Managers are still in the public property but exposes investments to the political and business cycle, harming the autonomy of the company. Additionally, if ownership separation involves forms of privatization at the upstream level with the Government not always able or willing to intervene for financing investments and cover the related costs, then it may not be so appealing. However, in this second case, further investigation will be needed for the definition of the access charge (which is equal to the mark- up in our simplified setting) since the regulator would not be directly able to verify the exact marginal cost and sets the related access charge. This would not happen in the case of public firms since communication between a public (but independent) entity as the regulator and a public firm is supposed to be easier or at least less affected by moral hazard or opportunistic behaviours. Instead, for access charges higher than a certain threshold, vertical integration has to be preferred and this would lead the firm to care jointly about the upstream and downstream sides of the market, enabling for investments although likely to be involved in discriminatory behaviours.

Further extensions may also be devoted to consider demand-reducing sabotage, which is quite important in quantity competition (Mandy and Sappington 2007) as well as investment incentives, which are clearly relevant in the rail industry for ensuring the system to work autonomously. In this regard, for instance, Chen and Sappington (2009) study optimal pricing rules incentivizing upstream process innovation finding that these are more effective when there is vertical integration as long as downstream firms compete in quantity. Likewise, Chen and Sappington (2010) argue that incentives for innovation for the upstream provider are dependent on the shape of the competition in the downstream market with vertical integration promoting more process innovation when quantity is the choice variable while this is inhibited under price competition.

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