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Merger incentives under yardstick competition: A theoretical model*

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Abstract

Are the incentives for firms to merge horizontally under yardstick regulation actually aligned with social and consumer welfare? Natural monopoly operators regulated by yardstick competition, such as electricity network operators and water distribution utilities, have merged repeatedly in recent years. In the context of regulated network industries, yardstick competition implies that firms compete on costs, given that their revenue allowance is based on cost observations from similar firms (peers). Whereas regulators have raised concerns about horizontal mergers under yardstick competition, traditional economic theory suggests that this restructuring should not lead to (unilateral) anticompetitive effects. In our theoretical model, by contrast, firm incentives for horizontal mergers involving peers are only aligned with social and consumer welfare if efficiency gains are sufficiently large. We go on to show how regulators can better align firm incentives with welfare considerations and limit the need for costly merger control by adapting the yardstick regime to the domestic industry structure.

Keywords: Yardstick Competition, Merger Analysis, Utility Regulation.
JEL classification: L51, L40, L11

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1 Introduction

Local natural monopolies that are regulated by yardstick competition, such as gas and electricity network operators as well as water distribution utilities, frequently merge.[1] Since the 1990s, hundreds of such mergers took place in various European countries, including Denmark (Danish Energy Regulatory Authority, 2015), Germany (European Commission, 2010a,b), the Netherlands (Dijkstra et al., 2014), Norway (Agrell et al., 2015) and the UK (Oxera, 2016). In network industries, yardstick competition is a popular regulatory tool in which a firm's revenue allowance is based on cost observations from similar firms—firms are benchmarked against their peers (Haney and Pollitt, 2013). The theory of regulation shows that yardstick competition among identical firms not only provides all firms with incentives for cost minimisation, but can also prevent them from making economic profit, meaning that firms cannot extract an information rent from the regulator (Shleifer, 1985). Unobserved heterogeneity across firms, which is inevitable under real-world circumstances, implies that firms will make positive economic profit on the idiosyncratic, firm-specific part of their costs (Auriol and Laffont, 1992).

However, the existing theoretical literature assumes that the industry structure is exogenously given and does not consider the possibility that firms strategically manipulate the peers to their advantage—with the exception of the extreme case of a merger-to-monopoly (Auriol and Laffont, 1992; Tangerås, 2002). Thus, unlike Cournot mergers, where the welfare trade-offs are well understood (Farrell and Shapiro, 1990),[2] yardstick mergers have not yet been subject to rigorous theoretical scrutiny beyond the duopoly-monopoly setting. By contrast, the empirical literature suggests that strategic firm behaviour, or gaming, is a critical issue under regulatory benchmarking (Jamasb et al., 2004). Specifically, it is argued that mergers in regulated industries may harm consumers as industry consolidation shrinks the regulator's information base (Jamasb and Pollitt,

[1] Note that in liberalised network industries such as electricity and natural gas in the European Union, yardstick competition is only relevant for the natural-monopoly segment of the supply chain, i.e. network operation. Price setting in the unbundled competitive segments of the supply chain (in electricity this refers to generation, storage and retailing) is at the commercial discretion of the companies. Also note that yardstick competition is relevant for hospitals as well, where it is also believed to have triggered mergers (Schmid and Varkevisser, 2016).

[2] For an introduction to mergers in competitive markets, see Motta (2004).

2003; Bogetoft and Otto, 2011; Ofwat, 2015).

We therefore develop a theoretical model of yardstick competition that allows for strategic firm behaviour in the form of horizontal mergers.[3] If the efficiency gains are large enough, firms will pursue mergers that lead to lower prices for consumers (at least on average). However, we also demonstrate that anticompetitive mergers can be firm-level rational—even those that *raise* the merging parties' costs and decrease social welfare (perverse incentives). The reason is that a merger involving at least one peer firm further improves the insiders' competitive position if it removes a relatively efficient firm from their reference set. Analogously, when the yardstick also includes inefficient firms, firms that are less efficient than their reference set will be deterred from proposing welfare-increasing mergers (missing incentives) unless efficiency gains are large enough.

The article is policy relevant as it clarifies how horizontal mergers can affect prices in network industries regulated by yardstick competition. The analysis could therefore enable regulators to adapt the design of the yardstick scheme to the local industry structure and facilitate the work of competition authorities. When the number of peers a firm can be compared to is large, the regulator can generally avoid distortions of merger incentives by limiting the influence any one firm exerts on other firms' prices, e.g. by using an average-cost yardstick regime. By contrast, when there are only few potential peers, a best-practice regime (where prices are only based on the industry's most efficient firms) could be superior as it avoids the issue of missing incentives and limits the share of potential mergers that would require costly merger control.

The article is organised as follows. We first review the existing literature on yardstick competition; pointing out that unilateral effects of horizontal mergers have so far not been analysed theoretically, despite their practical relevance. We then introduce our formal model and analyse merger incentives under average-cost yardstick regime, with our baseline thus being line with the theoretical literature (Shleifer, 1985; Meran and von Hirschhausen, 2009). We then go on to discuss practically relevant modifications to the average-cost yardstick

[3] Vertical mergers, where the network operator would integrate with retailers or generators would naturally introduce heterogeneity that potentially increases the information rents for the firms, as well as a range of direct anticompetitive effects due to discriminatory access and strategic pricing. However, given the European unbundling requirements for network operators, we restrict our attention to horizontal mergers within the same jurisdiction.

regime, especially best-practice regulation. Conclusions include policy recommendations.

2 Related literature

In the original theory of yardstick competition (Shleifer, 1985), and generally in standard multiple-agent models with correlated private information (Crémer and McLean, 1985), the regulator can do away with all heterogeneity without conceding an information rent to firms (full-information outcome)—a result sometimes referred to as the Crémer-McLean paradox. In the former model, the regulator can correct for all differences across firms using econometric techniques, and then simply set a firm's remuneration equal to the average cost of the other firms. In the latter framework, both regulator and firms are assumed to have well-defined Bayesian priors on these differences which enable the regulator to costlessly elicit the firms' true type. If heterogeneity is not a problem, merger incentives are trivial as the regulator is able to induce the first-best outcome and there is consequently no room for strategic firm behaviour provided that at least two independent firms remain after a merger.

However, subsequent research shows that these results are an artefact of assumptions that do not hold under real-world circumstances. The full-information outcome can no longer be reached if one assumes that (i) firms are risk averse (Demski et al., 1988), (ii) feasible rewards and penalties are bounded e.g. because of limited liability (Lockwood, 1995), (iii) firms can collude (Laffont and Martimort, 2000; Tangerås, 2002), (iv) agents hold identical beliefs but have different preferences (Neeman, 2004), or (v) that a firm's cost function is additively separable into a an industry-specific part that is identical across all firms and a firm-specific share of costs that is not correlated across firms at all (Auriol and Laffont, 1992; Meran and von Hirschhausen, 2009).

These theoretical concerns have been echoed by regulators (Ofwat, 2015), applied economists (Jamasb and Pollitt, 2003; Bogetoft and Otto, 2011) and econometricians (Greene, 2005) who emphasise that unobserved heterogeneity across firms is a prevalent characteristic under real-world circumstances that cannot be entirely circumvented by mechanism design. If unobserved heterogeneity forces regulators to award firms with some information rent to induce efficient operation, firms can be expected to strategically exploit such hetero-

geneity. They could, for example, attempt to strategically change the industry structure in their favour by merging with other operators, selling off parts of their business or reorganise their operations to fare better in the benchmarking exercise—even when such actions do nothing to improve productive efficiency. What do we know about such strategic firm behaviour under yardstick competition?

As mergers are the most commonly observed form of strategic behaviour in regulatory practice, the theoretical literature and our article focus on this phenomenon. Auriol and Laffont (1992) and Fiocco and Guo (2015) study the special case of a merger-to-monopoly. In their models, yardstick competition reduces firm rent; firms hence find it profitable to merge to monopoly. The regulator's problem is then to decide whether the merger gains—decreased fixed cost in the Auriol-Laffont model, positive externalities on the competitive segment of the supply chain in Fiocco and Guo—outweigh the increase in information rent. In most real-world circumstances, firms will, however, not be able to consolidate the entire industry to bring down the yardstick scheme.[4] It then becomes interesting to study merger effects in the more common setting in which firms are exposed to yardstick competition before and after a merger.

To the best of our knowledge, the only theoretical article that looks at mergers beyond the duopoly-monopoly setting is Dijkstra et al. (2014), which studies coordinated merger effects. Their model of uniform yardstick competition, complemented by experimental evidence, suggests that mergers that decrease firm-size heterogeneity facilitate collusion. Our theoretical analysis differs in three main ways. First, we show that yardstick mergers come with a trade-off even when the discriminatory yardstick in the tradition of Shleifer (1985) is used.[5] Second, we account for the possibility that firms' production possibilities are not identical. Third, we demonstrate the existence of *unilateral* (non-coordinated) anticompetitive effects resulting from yardstick mergers. In other words, yardstick mergers could not only cause coordinated effects, but may harm consumers and decrease social welfare even in a setting that does not

[4]Bringing down a yardstick scheme is arguably easier by using political and judicial means as in Belgium (Agrell and Teusch, 2015) or in Sweden (Agrell and Grifell-Tatjé, 2016).

[5]Discriminatory yardstick competition means that a firm's own cost does not affect its price. Under uniform yardstick competition on the other hand, a firm's own cost affects its revenue allowance, potentially providing firms with incentives to inflate their expenditure (see Section 5.1).

allow for tacit collusion.[6]

3 The model

3.1 Demand side

In this one-period model inspired by Shleifer (1985) and Meran and von Hirschhausen (2009), consumers living in region $i \in S = \{1, 2, ..., n\}$ demand to be connected to a network infrastructure service that qualifies as a natural monopoly, such as electricity and natural gas networks or water supply and sewerage. Regional demand $q_i \in \mathbb{R}_+$ for the service is perfectly inelastic but may vary across regions, e.g. because concession areas are of different size or population density. q_i could, for example, be the number of households that are connected to the energy or water network located in region i.[7] Consumer surplus in region i is:

$$V_i(p_i) = (r - p_i)\ q_i \tag{1}$$

where $r \in \mathbb{R}_+$ is the consumer's reservation price, also known as pain point. Consumers thus only purchase the service if $r \geq p_i$.

3.2 Supply side

The service is supplied by n local monopolists, also subscripted i according to the region for which they have a concession to operate. The positive unit cost incurred by firm i is denoted by $c_i \in [\underline{c}_i, \overline{c}_i]$. Here, $\underline{c}_i$ is the lowest feasible unit cost in concession area i (i.e. the unit cost of a cost-minimising firm). Minimum unit costs may differ across regions because of economies of scale and scope, some firms having access to better technologies than others (e.g. because of legacy assets), scarce managerial skills, and regionally diverging operating

[6] As we model yardstick competition as a finite-horizon game, which makes sense given that regulatory periods usually only last for four to five years, tacit collusion cannot emerge (Belleflamme and Peitz, 2015).

[7] Demand elasticity for such essential infrastructure services is known to be extremely low and mainly related to quality aspects that are often regulated separately. Demand is therefore largely beyond the operator's control. Stylising this fact for analytical clarity, we assume perfectly inelastic demand. The trade-off in terms of generality is low as in the context of network industries welfare distortions associated with monopoly pricing under elastic demand could be avoided by allowing the monopolist to charge discriminatory two-part tariffs (Sobel, 1999).

conditions. A priori, firms are, of course, free to spend more than is necessary to deliver the service as long as the resulting unit cost does not exceed the upper bound $\overline{c}_i$.[8]

Firm profits are:

$$\pi_i(p_i, c_i) = (p_i - c_i)q_i. \tag{2}$$

Firms maximise utility consisting of profit and slack, which we define as difference between observed and minimum cost:

$$U_i(p_i, c_i) = \pi_i(p_i, c_i) + \rho(c_i - \underline{c}_i)q_i \tag{3}$$

where $\rho \in (0, 1)$ is a parameter that determines how much the firm values slack relative to profit. One Euro of excess cost has the value of ρ Euro in profit that could be paid out to owners or managers, e.g. in the form of dividends.[9] Note that the firm will always prefer one Euro of profit to the equivalent in slack. However, the closer ρ is to one, the more owners also derive utility from spending company money. Publicly-owned firms could, for instance, value a large workforce for political reasons. And even private operators may derive some utility from slack, e.g. because it allows them to sponsor a local sports team, drive upmarket company cars or hold board meetings in luxury settings. We normalise the firms' reservation utility to zero.

3.3 Full-information outcome

What would be the outcome if the regulator was omniscient and omnipotent? Defining regional welfare as the unweighed sum of regional consumer surplus and firm profit, $V_i + \pi_i$, welfare simplifies to:

$$W_i(c_i) = (r - c_i)q_i \ \forall i \in S. \tag{4}$$

A welfare-maximising regulator would then order firms to minimise production costs:

[8] A rationale for the existence of $\overline{c}_i$ could be regulatory, judicial, political or public oversight of the firm's activities that imply some limit to the amount of spending the firm can engage in without getting in trouble. Alternatively, one may view $\overline{c}_i$ as the historical cost level, and $\underline{c}_i$ the cost level that results after some optimal cost-reducing investment. This would then more closely resemble the Shleifer model.

[9] Our treatment of slack corresponds to assuming a linear cost of effort. We make it depend on q to account for the fact that slack is easier to hide in larger organisations.

$$c_i^* = \underline{c}_i \ \forall i \in S. \tag{5}$$

As demand is inelastic, absent distributional preferences any price $p_i \in [\underline{c}_i, r]$ would achieve the social optimum. However, regulators are commonly assumed to attach greater weight to consumers (Laffont and Tirole, 1993). Competition authorities tend to favour consumers in their welfare considerations as well (e.g. European Commission (2004)). We incorporate this into the analysis by assuming that the regulator favours consumers if two prices are otherwise welfare equivalent. Distributional preferences thus enter to break ties in favour of consumers. Prices are then socially optimal if and only if the firms' participation constraints are binding:

$$p_i^* = \underline{c}_i \ \forall i \in S. \tag{6}$$

3.4 Information structure and timing

In real-world settings, the regulator cannot order firms to produce at the socially optimal level; first and foremost due to a lack of knowledge on the firms' production possibilities. To capture this informational constraint, we assume that the regulator is uninformed about the cost structure of the industry. More to the point, the regulator faces Knightian uncertainty with respect to $\underline{c}_i$. Unlike in Bayesian models such as Auriol and Laffont (1992), the regulator thus does not know the distribution of $\underline{c}_i$ across firms. This is a response to concerns that principal-agent models overestimate regulators' informational endowment (Crew and Kleindorfer, 2002; Macher et al., 2011) and a straightforward way to circumvent the Crémer-McLean paradox discussed in Section 2. The regulator is, however, aware to be unaware and knows that the firms production possibilities are different. In addition, the level of service q_i delivered by the firms can be observed ex post, as well as the prices charged and the costs incurred by the firms.

Firms, on the other hand, are fully informed, i.e. they know the range of feasible costs as well as the demand for the entire industry. Formally, this corresponds to knowing the full vectors $\underline{\mathbf{c}}_i, \overline{\mathbf{c}}_i$ and $\mathbf{q}_i$. The premise that firms in an industry know more about each other than the regulator, also implicit in Meran and von Hirschhausen (2009), seems reasonable, especially in the context

of network industries such as electricity, natural gas or water where the product (or service) is quite homogeneous.

Our model thus focuses on the vertical information asymmetry between regulator and firms. The timing is as follows:

1. Regulator announces pricing rule
2. Firms learn about the vectors of cost and demand parameters $\underline{\mathbf{c}}_i, \overline{\mathbf{c}}_i, \mathbf{q}_i$
3. Firms simultaneously and independently choose c_i and p_i before delivering the service q_i
4. Regulator observes vectors of service levels $\boldsymbol{q_i}$, prices charged to consumers $\boldsymbol{p}_i$ and the firms' expenses, based on which unit costs $\boldsymbol{c}_i$ can be calculated.

3.5 Regulatory options

Given their informational constraints, how can regulators motivate firms to minimise costs and keep prices at levels acceptable to consumers? If regulators refrain from economic regulation, firms do minimise costs, but can also extract the entire social surplus by setting prices equal to consumers' reservation price, i.e. $p = r$. At least in the developed world where consumers' willingness to pay for essential infrastructure services is high, this would lead to substantial excess profits for suppliers and one would expect public outrage of captive consumers. What are the regulator's options to avoid this scenario?

The traditional choice is the cost-recovery regime. If the regulator announces to reimburse firms for all costs incurred (cost-of-service or rate-of-return regulation), owners' utility (3) would simplify to $\rho(c_i - \underline{c}_i)q_i$. Firms would thus want to introduce as much slack in the production process as possible and therefore choose $\overline{c}_i$. The reason is that if minimising costs does not increase profits, firms prefer higher costs as in Shleifer (1985). This result is perfectly standard in the principal-agent literature where it is commonly obtained by assuming that lower costs come with a disutility of effort (e.g. Laffont and Tirole (1993)).

A way to avoid the input-mix distortions of cost-recovery regimes (Averch and Johnson, 1962) is a price-cap (or revenue-cap) regulation (Beesley and Littlechild, 1989). In this case, p would be determined by the regulator. As firm revenue then is independent of performance, firms will find it optimal to minimise costs and choose c^*. The key informational challenge associated with this

regime is to determine the size of the cap—if $p > p^*$ firms make excessive profits, if $p < p^*$ firms would exit the industry. How can regulators resolve this information asymmetry?

Whereas the scholarly literature has identified a number of theoretically promising regulatory options to bridge the information gap, including menus of contracts (Laffont and Tirole, 1993), franchise auctions (Demsetz, 1968), engineering norm models (Jamasb and Pollitt, 2008) and profit-sharing schemes (Lyon, 1996; Schmalensee, 1989), regulators have rarely been able to apply these in infrastructure industries such as energy and water networks.[10]

Contrastingly, yardstick competition has neat properties not only in economic theory (Shleifer, 1985; Auriol and Laffont, 1992), but has also been repeatedly and successfully implemented in regulatory practice in Europe and beyond (Haney and Pollitt, 2013). Even in countries that do not have pure yardstick regimes in place, benchmarking exercises frequently inform price-cap and cost-recovery regimes. In the former case, yardstick competition allows regulators to determine the appropriate size of price caps and defend their accuracy in a court of law. In the latter it guides the regulator in screening planned expenditures ex ante and/or helps determining whether costs were efficiently incurred ex post. There is also some evidence that even in the absence of institutionalised yardstick competition, firms may face competitive pressures if regulatory agencies, consumers or courts can observe other firms that provide a comparable service under similar conditions (Kumbhakar and Hjalmarsson, 1998; Wallsten and Kosec, 2008). The next section shows how the regulator can apply yardstick competition under our knowledge assumptions.

3.6 Yardstick competition

The regulator can implement yardstick competition by capping a firm's revenue based on cost information from other firms in the industry. For now, assume that the regulator requests that a firm's price must not exceed the average unit cost of the other independent firms in the industry.[11] Formally the pricing rule is

$$p_i \leq c_{-i}^{\text{avg}} + \alpha_i, \ \forall i \in S \tag{7}$$

[10] For an overview of the theoretical literature see (Armstrong and Sappington, 2007). The implementation gap is discussed in Crew and Kleindorfer (2002) and Joskow (2013).

[11] We discuss another popular yardstick design, i.e. the best-practice regime, in Section 5.2.

where $c_{-i}^{\text{avg}} = \frac{1}{n-1}\sum_{j\neq i} c_j,\ \forall i \in S$ and $\alpha_i \in \mathbb{R}$ is a cost adder that the regulator announces *ex ante* to ensure that a firm's participation constraint is met. α_i could be based on regulatory experience or industry studies.[12].

Firms simultaneously and independently maximise their utility function subject to the regulatory constraint, i.e. the regulator's pricing rule, as well as the firm's participation constraint.

$$\max_{c_i,p_i} U_i = (p_i - c_i)\ q_i + \rho(c_i - \underline{c}_i)q_i \text{ s.t. } p_i \leq c_{-i}^{\text{avg}} + \alpha_i \text{ and } U_i \geq 0. \tag{8}$$

As the firm's own cost choice does not influence the price it is allowed to charge, and firms prefer profit over slack, firms will minimise costs such that:

$$c_i^0 = \underline{c}_i,\ \forall i \in S, \tag{9}$$

where superscript 0 indexes the pre-merger equilibrium (whereas the post-merger equilibrium discussed in the next section will be indexed by superscript 1).

As demand is inelastic choosing the highest possible price does not decrease the demand for the regulated service. Firms will thus always set the highest price that does not violate the regulator's pricing rule:

$$p_i^0 = \underline{c}_{-i}^{\text{avg}} + \alpha_i,\ \forall i \in S. \tag{10}$$

Equation 10 holds because firms are aware of the other firms' production possibilities and therefore know their comparators' best responses to the pricing rule. Compliance with the pricing rule hinges on the conventional assumption of *ex-post* verifiable costs and prices and the possibility of penalties in the case of non-compliance. Notice, however, that the regulator does not need to know the firms' production possibilities. Observing ex-post values of total costs, prices and output is sufficient to implement the regulatory mechanism.

In equilibrium, the pre-merger utilities are then:

$$U_i^0 = (\underline{c}_{-i}^{\text{avg}} + \alpha_i - \underline{c}_i)q_i,\ \forall i \in S. \tag{11}$$

[12] Meran and von Hirschhausen (2009) use dynamic game theory to endogenise α_i by creating a lagged adjustment mechanism. As the main focus of this model is on merger incentives, we prefer to treat α_i as time independent to avoid that α_i interfere with the merger analysis. Note that whereas our assumptions on α imply that firms will minimise cost, prices should generally be above the social optimum as the regulatory is unlikely to have the information necessary to set α_i to the level where the firm's participation constraint is binding (see Section 2).

Three things are noteworthy. First, even though firms are not assumed to be only profit maximising, in equilibrium they will behave as if they were and not choose any slack ($U_i^0 = \pi_i^0,\ \forall i \in S$). We can therefore limit our analysis of merger incentives under yardstick competition to the profitability of mergers without loss of generality.[13]

Second, absent productivity differences across firms ($\underline{c}_i = \underline{c}_j,\ \forall i, j \in S$), firms do not make any economic profit (information rent) as long as the regulator is aware of the lack of heterogeneity and sets $\alpha_i = 0,\ \forall i \in S$. As discussed in Section 2, this finding is well-established in the principal-multiple agent literature for agents with correlated private information.

Third, notice that a firm's utility/ profit increases in the cost of its competitors. Firms costs are strategic complements—similar to prices under Bertrand competition. Firms would thus have an interest to increase the costs of their competitors. In this respect, the literature has mainly focused on collusion (Tangerås, 2002; Dijkstra et al., 2014) and the lack of investment incentives if the entire industry would benefit from the resulting cost-reducing innovation (Dalen, 1998). We consider a novel strategy to increase profit under yardstick competition in a potentially legal manner: horizontal mergers.

3.7 Horizontal mergers

We model yardstick mergers by considering that $h \geq 2$ merging parties, indexed $m \in M \subset S$ according to the region in which they operate, consolidate their activities. They can do so at Step 2 of the timing outlined in Section 3.4. As firms cannot combine network infrastructures such as electricity cables or water pipelines in the way other companies can bundle production in one location, we assume that the insiders retain regionally separate subunits. We consequently continue to refer to the regional branches of the merged entity by using the same regional index numbers as before. The post-merger equilibrium costs and prices are indexed by superscript 1. To ensure that firms still compete after a merger, we assume that at least one outside firm, indexed $o \in S \setminus M$, remains ($n - h \geq 1$).

We allow mergers to change the cost structure of the insiders such that the new minimum unit cost the regional subunits of the merged entity will set in

[13] Slack will become relevant again in Section 5.1 where we discuss the case where a firm's observed cost also influences its revenue cap.

equilibrium is:

$$c_m^1 = \underline{c}_m - x \tag{12}$$

where $x \in \mathbb{R}$ captures the efficiency effect of a merger on the minimum cost of subunit m.[14] If $x > 0$, the merger brings efficiency gains. Efficiency gains could stem from economies of scale in procurement, staffing or from access to scarce managerial or technical resources (Roeller et al., 2006). If $x < 0$, by contrast, the insiders' productivity is decreased, for example because of transaction costs and organisational diseconomies of scale (Grossman and Hart, 1986; McAfee and McMillan, 1995). Efficiency-decreasing mergers appear to be surprisingly common in practice (Cronin and Motluk, 2007b; Kwoka and Pollitt, 2010). In line with our previous assumptions on the information asymmetry between regulator and firms, outsiders observe x whereas the regulator does not.

Lemma 3.1. *Mergers increase (decrease) social welfare if and only if there are efficiency gains (losses).*

Proof. Straightforward from Equation 4. □

The intuition behind Lemma 3.1 is clear. If we do not care about distributional issues (apart from the tie-breaking rule introduced in Section 3.3), price effects of a merger do not matter in a setting with perfectly inelastic demand. Welfare effects are then positive if costs go down which only materialises if a merger brings efficiency gains.[15]

After a merger, we assume that the regulator removes the regional subunits from the merging entity's reference set which is what we typically observe in practice (e.g. Agrell et al. (2015)). The theoretical rationale is that firms could otherwise strategically allocate costs between subunits or refrain from cost-minimisation (see Section 5.1). Consequently, after a merger the insiders

[14] The assumption that x applies symmetrically to all subunits of Merger M is for notational convenience. Also note that the assumption that costs are always positive (see Section 3.2) implies an upper bound for x.

[15] A competition authority that only takes the unweighed social surplus criterion into account should consequently clear all mergers that are expected to bring synergies. However, as discussed earlier, real-world competition authorities tend to place a higher value on consumer surplus and often focus on price effects. In addition, efficiency-increasing mergers are not necessarily firm-level rational for the potential merging parties. The subsequent section addresses these issues.

only respond to the outsiders' cost-minimising production choices when setting prices:

$$p_m^1 = \frac{1}{n-h} \sum_o \underline{c}_o + \alpha_m \ \forall m \in M. \tag{13}$$

The outsiders' equilibrium prices now are:

$$p_o^1 = \frac{1}{n-1} \left(\sum_{-o} \underline{c}_{-o} + \sum_m (\underline{c}_m - x) \right) + \alpha_o \ \forall o \in S \setminus M. \tag{14}$$

4 Results

To determine whether the firms' merger incentives are aligned with consumer and social welfare, we compare the hypothetical post-merger equilibrium, superscripted 1, to the pre-merger state of the world (denoted by superscript 0). We start off with the price effects of potential mergers, before determining:

- the required level of efficiency gains to make mergers both profitable and welfare-increasing;
- the conditions for privately profitable and welfare-decreasing mergers;
- the conditions for socially-desirable mergers that are not privately profitable;
- the externalities on outside firms and consumers.

To avoid notational complexity and facilitate the discussion of our results, we assume regional demand q_i be identical across regions and normalise it to 1. We can then break down merger incentives to the magnitude of *ex-ante* productivity differences between insiders and outsiders defined as:

$$\Delta \underline{c} = \underline{c}_o^{\text{avg}} - \underline{c}_m^{\text{avg}} \tag{15}$$

where $\underline{c}_m^{\text{avg}} = \frac{1}{h} \sum_m \underline{c}_m$ denotes the average production possibilities of insiders before the merger, whereas the corresponding measure for outsiders is defined by $\underline{c}_o^{\text{avg}} = \frac{1}{n-h} \sum_o \underline{c}_o$. When $\Delta \underline{c} > 0$ insiders are on average more efficient (have lower minimum cost) than outsiders. When the opposite holds ($\Delta \underline{c} < 0$), insiders are on average less efficient.

4.1 Price effects

Denote regional price effects of a potential merger by $\Delta p_i = p_i^1 - p_i^0$. Plugging in Equation 14 and Equation 10 for p_i^1 and p_i^0, respectively, allows us to express price effects in a region operated by the outsiders as:

$$\Delta p_o = -\frac{hx}{n-1} \ \forall o \in S \setminus M. \tag{16}$$

The equation shows that prices in outsider regions only change if the insiders' cost structure changes, i.e. $x \neq 0$. This is because outsiders still choose the highest possible price given the optimal cost choices of all other firms. Outsiders will thus only choose a different price if the insiders minimum cost changes which requires $x \neq 0$ (see Equation 12). Ceteris paribus, the magnitude of the price effect increases in the number of merging parties h and decreases in the size of the industry n.

Subtracting Equation 10 from Equation 13 allows us to also identify price effects in insider regions:

$$\Delta p_m = \frac{1}{n-h} \sum_o \underline{c}_o - \frac{1}{n-1} \left(\sum_o \underline{c}_o + \sum_{-m} \underline{c}_{-m} \right) \ \forall m \in M. \tag{17}$$

Equation 17 is noteworthy for two reasons. First, the outsiders' influence on any insider's price increases after the merger ($\frac{1}{n-h} > \frac{1}{n-1}$) because the other insiders are removed from the insider's set of comparators. Second, x does not feature in the equation. Put verbally, the effect of a merger on the insiders' prices is not due to any changes in the insiders' efficiency levels. It is thus a pure peer effect. Again, the magnitude of the price effect increases in the number of insiders and decreases in the size of the industry.

Corollary 4.1. *Mergers with efficiency gains (losses) decrease (increase) prices and profits in regions not involved in the merger. Irrespective of efficiency gains, prices in insider regions decrease (increase) if the other merging parties are ex-ante less (more) efficient than the average outsider.*

Proof. The outsider price effect is straightforward from Equation 16. The effect on outsider profits (Equation 2) is due to the fact that the outsiders' costs do not change. Since demand is fixed by assumption, a price decrease harms outside firms. To see that prices in insider regions can only decrease if the other insiders are ex-ante less efficient than the average outsider, set Equation 17 to

less than zero. After some rearranging $\Delta p_m < 0$ yields: $\frac{1}{h-1} \sum_{-m} \underline{c}_{-m} > \frac{1}{n-h} \sum_o \underline{c}_o \ \forall m \in M$. Prices increase if the opposite holds. □

Corollary 4.1 establishes that if there are efficiency gains, i.e. $x > 0$, prices in regions not involved in the merger decline which hurts outside firms but benefits their respective consumers. The reason is that after such mergers the outsiders are competing against a more efficient reference set and therefore have to lower their price. A merger bringing efficiency gains hence comes with a positive consumer externality.[16] By contrast, when a merger reduces the insiders' productivity, we are confronted with a negative externality as outsiders react by increasing prices. An insider, on the other hand, can charge a higher price if the other insiders (those that were removed from its reference set) were on average more efficient than the average outsider *before* the merger. This is because in this case after merging the insider is compared to a relatively less efficient reference set only consisting of the outsiders.

Lemma 4.2. *A merger increases aggregate consumer surplus if and only if the efficiency effect is above the threshold* $\phi_p = \frac{h-1}{n-h} \ \Delta\underline{c}$.

Proof. First note that the impact of a merger on regional consumer surplus is identical to the price effect as demand q_i and consumers' willingness to pay r are both constant by assumption (Equation 1). Given that q_i is normalised to 1 $\forall i \in S$, summing up Equation 16 over all outsiders yields the aggregate change in the outsider regions' consumer surplus: $\sum_o \Delta p_o = -\frac{(n-h)hx}{n-1}$. Analogously, summing up Equation 17 over all insiders yields: $\sum_m \Delta p_m = \frac{h \sum_o \underline{c}_o}{n-h} - \frac{h \sum_o \underline{c}_o + (h-1) \sum_m \underline{c}_m}{n-1}$. The sum of the two is the merger effect on aggregate consumer surplus: $\sum_i \Delta p_i$. Setting $\sum_i \Delta p_i < 0$ and solving for x reveals that aggregate consumer surplus only increases (i.e. average prices decrease) if $x > \frac{h-1}{n-h} \left(\frac{1}{n-h} \sum_o \underline{c}_o - \frac{1}{h} \sum_m \underline{c}_m \right)$ which corresponds to the threshold ϕ_p. □

The threshold ϕ_p shows that if the merging parties on average are more efficient than the outsiders before the merger ($\underline{c}_m^{\text{avg}} < \underline{c}_o^{\text{avg}}$), aggregate consumer surplus only increases if the merger brings sufficient efficiency gains. The reason is that in this case a merger will increase prices in the regions operated by the insiders. Such a merger is then only good for the average consumer if the price

[16] This effect depends on the existence of sufficiently positive outsider profits before the merger (see Footnote 12). If an outsider's participation constraint was binding before the merger, any price-decreasing externality would lead to the outsider's exit.

increase in the insider regions is compensated by lower prices in the regions operated by parties not subject to the merger (see Corollary 4.1 above).

On the other hand, if insiders are on average less efficient than outsiders ($\underline{c}_m^{\text{avg}} > \underline{c}_o^{\text{avg}}$), even some cost-increasing mergers would be in the interest of the average consumer. This is because after such a merger prices in insider regions would decrease as the merging parties would compete against a more efficient reference set (whereas outsiders would set higher prices). However, we shall now see that whereas profit-maximising firms may sometimes propose cost-increasing mergers, they never do so when it would be in the interest of consumers. Also recall from Lemma 3.1 that such mergers would decrease social welfare.

4.2 Profitable mergers

Merging is profitable for the potential insiders if and only if joint insider profits after the merger are higher than before, i.e. $\sum_m \Delta\pi_m > 0$ where $\Delta\pi_m = \pi_m^1 - \pi_m^0$. As the preceding section has established the price effects of all theoretically possible merger proposals, and demand is constant by assumption, we can immediately formulate:

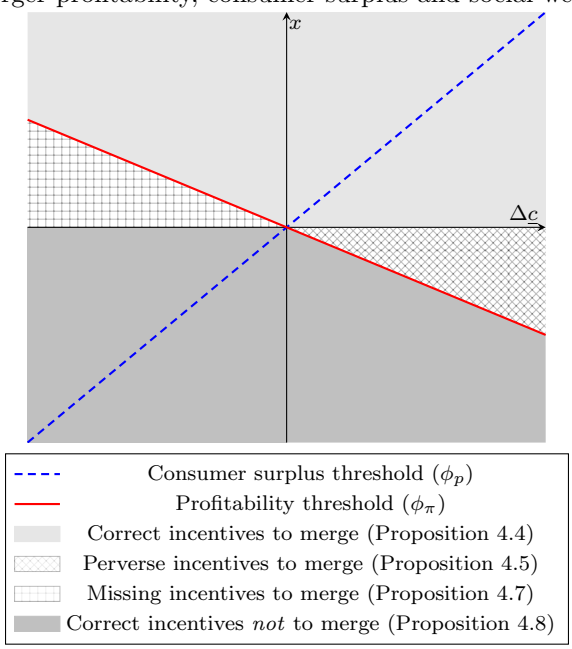
Lemma 4.3. *A merger is only profitable for the merging parties if the efficiency effect x is above the threshold $\phi_\pi = -\frac{h-1}{n-1}\ \Delta\underline{c}$.*

Proof. Recall that efficiency gains x accrue to all h insider regions (which represent the only cost effect of a merger) and that demand q_i is normalised to 1. The total profit effect across all insiders can thus be written as $\sum_m \Delta\pi_m = \sum_m \Delta p_m + hx$. Plugging in Equation 17 for Δp_m, setting $\sum_m \Delta\pi_m > 0$ and solving for x then yields $x > \frac{h-1}{n-1}\ \left(\frac{1}{h}\sum_m \underline{c}_m - \frac{1}{n-h}\sum_o \underline{c}_o\right)$, which is equivalent to ϕ_π. □

Figure 1 graphically illustrates our theoretical results on profitability, consumer surplus and social welfare. The figure is drawn for the three-firm case, but note that a larger industry size merely makes the slopes less steep (whereas more merging parties imply steeper slopes). Recalling Lemma 3.1, we know that all mergers above the x-axis increase welfare as they come with efficiency gains, whereas the ones below reduce the social surplus. The average consumer only benefit from mergers that are above the dashed line, i.e. ϕ_p (Lemma 4.2). Firms will propose all mergers that are above the solid line, i.e. above ϕ_π as

established by Lemma 4.3. We relegate the discussion of unprofitable merger possibilities (those below the solid line) to the next subsection.

Figure 1: Merger profitability, consumer surplus and social welfare ($n = 3$).



Proposition 4.4. *Mergers are both profitable and and welfare-increasing if and only if the efficiency effect is positive and above the threshold ϕ_π, i.e. $x > \phi_\pi > 0$.*

Proof. Follows from Lemmas 3.1 and 4.3. □

Proposition 4.4 refers to all merger possibilities shaded in light grey in Figure 1. The mergers located in the upper-right quadrant are both profitable for the insiders and welfare increasing since they bring efficiency gains to insiders that are on average already more productive than outsiders before merging. Merger incentives are aligned with social welfare as the merger decreases costs. Insiders additionally benefit from rising prices as their reference set (i.e. their peers) becomes less efficient.

In the upper-left quadrant, on the other hand, merger incentives are only aligned with welfare considerations if efficiency gains are sufficiently large. More to the point, firms will only propose such mergers if they are certain to be

compensated by efficiency gains $x > \phi_\pi$. The reason for this is that the mergers decrease prices in insider regions as, after merging, the insiders are confronted with a more efficient reference set.[17] Note that these latter mergers do not only increase the social surplus (Lemma 3.1) in their own region, but are also good for consumers as prices in outsider regions decrease as well (Corollary 4.1).

By contrast, mergers in the crosshatched area in Figure 1 are profitable for the firms yet decrease social welfare (and consumer surplus) as formalised in:

Proposition 4.5. *Mergers are privately profitable but decrease welfare if and only if the efficiency effect is negative yet above the profitability threshold, i.e.* $\phi_\pi < x < 0$.

Proof. Follows from Lemmas 3.1 and 4.3. □

The reason for these perverse incentives, i.e. firms proposing a merger that decreases their productivity, is that Proposition 4.5 implicitly requires that the insiders are ex ante more efficient than outsiders ($\Delta\underline{c} > 0$). Merging therefore increases prices in the regions operated by the insiders and as long as this price increase outweighs the efficiency losses associated with the merger, merging is individually rational for the insiders. Note that such mergers are always detrimental to consumers as prices do not only increase in the insider regions, but across all regions (see Corollary 4.1 above). Social welfare is also decreased as shown by Lemma 3.1. It should hence not be approved by the responsible competition authority.

Note that whereas mergers below ϕ_p in the upper-right quadrant increase social welfare, they also reduce aggregate consumer surplus since average prices rise. If the competition authority was only concerned with consumer surplus, it would thus not approve the merger. As a consequence, consumers only benefit from a subset of the privately profitable and welfare-increasing mergers:

Corollary 4.6. *Profitable and welfare-increasing mergers only increase (decrease) aggregate consumer surplus if the efficiency effect is above (below) the consumer surplus threshold* ϕ_p. *Profitable and welfare-increasing mergers only*

[17] Note, however, that even though these mergers increase welfare, they are not necessarily socially optimal. This is because firms faced with two efficiency-increasing alternatives to merge, might opt for the merger possibility with fewer efficiency gains if this leads to a less efficient reference set compared to the merger possibility with more efficiency gains.

increase (decrease) consumer surplus in all regions if no combination of insiders is ex-ante less efficient than the average outsider.

Proof. Follows from Lemmas 4.2 and 4.3 as well as Corollary 4.1. □

4.3 Unprofitable mergers

On the face of it, it may appear strange to discuss unprofitable mergers as these should a priori not be proposed by profit-maximising firms. But there are at least two reasons for which the issue deserves attention. First, empirical research suggests that a significant share of mergers that are implemented in the real world actually decrease company profits. Gugler et al. (2003), for instance, find that a staggering 43% of 2,753 analysed mergers decreased insider profits. The literature suggests that firms could propose such mergers because of managerial hubris or conflicting organisational objectives—vertically integrated operators may decide to merge to increase profits in other segments of the company.

Second, the network industries under yardstick competition are particular in that the (usually sectoral) regulator acts as a *de facto* market maker. The existing merger incentives are thus not the result of the unimpeded interaction of market forces, but a result of regulation. As a consequence, it could be feasible to change the rules of the game in order to improve on the incentives and stimulate welfare-increasing industry consolidation (see Section 5.3).

Proposition 4.7. *Socially-desirable mergers are not privately profitable if and only if the efficiency effect would be positive yet below the profitability threshold, i.e.* $0 < x < \phi_\pi$.

Proof. Follows from Lemma 3.1 and 4.3. □

Proposition 4.7 confirms what was established in the previous section; mergers are not profitable for relatively inefficient firms unless there are sufficient efficiency gains. Incentives are thus missing for those mergers that would bring some efficiency gains, but not enough to outweigh the price decrease of inefficient insiders. The missing incentives of the mergers are shaded with a gridded pattern in Figure 1. Remaining independent may, however, also be socially desirable as formalised in:

Proposition 4.8. *The decision of potential insiders not to merge is aligned with social welfare if and only if the efficiency effect would be negative and below the threshold ϕ_π, i.e. $x < \phi_\pi < 0$.*

Proof. Follows from Lemma 3.1 and 4.3. □

Mergers falling under Proposition 4.8 are shaded in dark grey. The proposition implies that merger incentives of relatively efficient insiders are aligned with social welfare if the transaction costs of a merger were to increase costs more than the revenue increase caused by the competitive effect. This is the case for all mergers below ϕ_π in the lower-right quadrant of Figure 1. Those firms that are on average less efficient than the average outsider will never find it profitable to propose welfare-decreasing mergers (all mergers in lower-left quadrant). The latter finding may facilitate merger control as the competition authority would only have to establish the relative competitive position of the insiders, and not need to carry out the informationally challenging task of assessing potential efficiency losses.

5 Remarks

5.1 What if a firm's own cost does influence its price?

Unlike in our model, in many real-world settings a firm's own cost does influences its price. This has a couple of potential benefits, but may prevent cost minimisation. The main advantage of having a firm's own cost be reflected in its price is that the benefit of local cost reductions is shared with local consumers. Recall from Corollary 4.6 that even mergers that improve productivity and increase aggregate consumer surplus do not necessarily benefit consumers living in the merging parties' region. As employment cuts and other socially unpopular effects of a merger do accrue locally, it may be politically desirable to ensure that the benefits in terms of lower prices materialise in the insider regions as well.

Let us therefore formally analyse the trade-off between productive efficiency and distributional concerns by adapting the pricing rule defined by Equation 7 to

$$p_i \leq \beta c_{-i}^{\text{avg}} + (1-\beta)c_i + \alpha_i, \ \forall i \in S \tag{18}$$

where $\beta \in [0,1]$ is a parameter measuring the relative weight the regulator attaches to the cost of other firms. If $\beta = 1$ we are back to standard yardstick competition. $\beta = 0$ corresponds to cost-of-service regulation discussed in Section 3.5. But what happens in the intermediate range, i.e. $0 < \beta < 1$?

As before, the pricing rule will be binding in equilibrium. Hence, firms are going to set $p_i = \beta c_{-i}^{\text{avg}} + (1-\beta)c_i + \alpha_i$. Plugging this into the firms' utility function (3) and simplifying yields

$$U_i(c_i) = \beta(c_{-i}^{\text{avg}} - c_i)q_i + \rho(c_i - \underline{c}_i)q_i + \alpha_i \tag{19}$$

Thus adding slack $c_i - \underline{c}_i > 0$ to the production process has two effects. On the one hand, slack increases firm utility by $\rho(c_i - \underline{c}_i)q_i$. At the same time, slack decreases utility by $-\beta(c_i - \underline{c}_i)q_i$. Only if $\beta > \rho$ will the latter outweigh the former and firms will be incentivised to minimise cost and refrain from slack. When determining the value of β, the regulator thus needs to pay due attention to how much firms value slack. The more firms value slack, the lower should be the influence of a a firm's own cost on the price it is allowed to charge.[18]

5.2 Best-practice regulation

In many applications of yardstick regulation, such as German and Norwegian electricity distribution, regulators do not base the revenue cap on all other firms in the industry, but only use cost-information from best-practice firms. To illustrate the advantages and drawbacks of this approach, we change Equation 7 to

$$p_i \leq \min\ \mathbf{c}_{-i} + \alpha_i,\ \forall i \in S \tag{20}$$

The price that firms are allowed to charge now only depends on the cost of the most efficient firm in its set of comparators (plus cost adder α_i), as opposed to the average of all firms. To simplify notation, let us sort firms by minimum cost (in ascending order) whereby index $i = 1$ refers to the firm with the best production possibilities. To avoid ties, also assume that no two firms are exactly

[18] Note that if we allow the value of slack to vary across firms, there will be distortions all across the industry even if only one firm has $\rho_i > \beta$. This is because under an average-cost yardstick regime, even firms with $\rho_i < \beta$ will set higher prices in response to the cost choices of firms with $\rho_i > \beta$.

identical. Firms will then optimally respond to the pricing rule by setting prices to

$$p_1^0 = \underline{c}_2 + \alpha_1,$$
$$p_i^0 = \underline{c}_1 + \alpha_i, \ \forall i \in \{2, ..., n\}$$

Thus, only Firm 1 and Firm 2 constitute the best-practice frontier. We index the subset of firms that have no influence on any other firm's price by $s \in \{3, ..., n\}$ Incentives for mergers involving only these firms are aligned with social welfare because such mergers do not change the insiders' price. Firm will thus find it optimal to merge if this allows them to reap efficiency gains and refrain from doing so otherwise. Note that if efficiency gains are large enough for the merged entity to replace one or both of the frontier firms, such a merger comes with a positive consumer externality. Under best-practice regulation, most potential mergers thus do not carry the risk of the kind of incentive distortions identified in Section 4.

Contrastingly, there are potentially perverse merger incentives with respect to mergers involving peer firms. To see this, consider a merger between Firm 1 and a subset of the firms indexed $s \in \{3, ..., n\}$. Proceeding as in Section 4, price changes in insider regions are:

$$\Delta p_1 = 0, \tag{21}$$
$$\Delta p_s = \underline{c}_2 - \underline{c}_1, \ \forall s \in M \tag{22}$$

The aggregate price change for the merging parties then is $\sum_m \Delta p_m = (h-1)(\underline{c}_2 - \underline{c}_1)$. The insiders' price will thus always increase as Firm 1 is removed from the reference set and replaced by Firm 2 with higher minimum cost ($p_s^1 = \underline{c}_2 + \alpha_s, \forall s \in M$). Such a merger is thus profitable for the insiders—provided the price increase is not offset by an efficiency effect below the (negative) profitability threshold $\phi_\pi = -(h-1)(\underline{c}_2 - \underline{c}_1)/h$. Perverse incentives result for any such merger with a negative efficiency effect of $\phi_\pi < x < 0$.

The external effect of the merger depends on whether it is (a) the merged entity or (b) Firm 2 that becomes the most-efficient firm after the merger. Scenario a materialises if $\frac{\sum_m \underline{c}_m}{h} - x < \underline{c}_2$. Consumers in outside regions then benefit if efficiency gains are sufficiently large, but face higher prices otherwise:

$$\Delta p_o^a = \left(\frac{\sum_m \underline{c}_m}{h} - x \right) - \underline{c}_1, \ \forall o \in S \setminus M \tag{23}$$

The merger increases aggregate consumer surplus if efficiency gains are above $\phi_p^a = \frac{\sum_m \underline{c}_m}{h} - \underline{c}_1 + \frac{h-1}{n-h}(\underline{c}_2 - \underline{c}_1)$.

In Scenario b, i.e. $\frac{\sum_m \underline{c}_m}{h} - x > \underline{c}_2$, prices in outside regions are certain to increase by

$$\Delta p_o^b = \underline{c}_2 - \underline{c}_1, \ \forall o \in S \setminus M \tag{24}$$

which implies that consumer surplus always decreases—there is no admissible value for ϕ_p^b as x does not affect any price (see Equations 21 and 22). (If x was sufficiently large, we would, of course, be in Scenario a.)

5.3 Comparison of yardstick regimes

How do the merger effects under best-practice regulation compare to the results we derived for the average-cost yardstick in Section 4? The main benefit is that using a best-practice yardstick does away with the issue of missing incentives identified for average-cost yardstick competition (see Proposition 4.7). This is because under best-practice regulation merging will never expose insiders to a more efficient reference set. In addition, perverse incentives are only a possibility for the subset of potential mergers that involve frontier firms.

There are, however, two drawbacks. First, whereas perverse incentives only concern a smaller subset of potential mergers, the associated welfare losses could be greater. To see this, let us compare potential welfare losses denoted L_W between (A) average-cost yardstick competition to (B) best-practice regulation. Recognising that the negative of the profitability threshold ϕ_π represents the upper bound for the efficiency losses of an insider (if losses were greater, firms would no longer find it profitable to propose the merger), industry-wide potential welfare losses of a given merger possibility losses are simply $L_W = -h\phi_\pi$:

$$L_W^A = \frac{(h-1)h}{n-1}\Delta\underline{c} \ , \ \forall \Delta\underline{c} > 0 \tag{25}$$

$$L_W^B = (h-1)(\underline{c}_2 - \underline{c}_1) \ , \ \forall i = 1 \in M, i = 2 \notin M. \tag{26}$$

Whereas under an average-cost yardstick regime the potential welfare losses of a given merger M go to zero as the number of firms increases, under best-practice regulation the effect size is not directly affected by the number of firms.

As a result, best-practice regulation implies that perverse incentives can even occur in industries with a large amount of *potential* peers $(n - h)$.[19]

The second drawback is related to a merger's distributional effects. Under average-cost yardstick regimes efficiency-increasing mergers always benefit consumers served by outsider firms and may even benefit all consumers (Corollary 4.6). Aggregate consumer surplus increases if efficiency gains exceed the threshold derived in Lemma 4.2. Under best-practice regulation, on the other hand, efficiency gains only increase aggregate consumer surplus if gains are so large that the merged entity becomes industry best-practice after the merger (see Section 5.2). If this condition is not met, efficiency-increasing mergers do not benefit consumers at all.

6 Conclusions

This article has shown that merger incentives of firms regulated by yardstick competition may be distorted. In particular, our theoretical analysis emphasised that firms may face perverse merger incentives under both average-cost and best-practice yardstick competition. With respect to the former regime, we additionally identified the possibility that firms lack the incentives to propose welfare-increasing mergers (missing incentives). Under what conditions are distorted merger incentives a relevant policy problem?

Naturally, any incentive distortions depend on there being unobserved heterogeneity between firms. As shown in this article, if firms are ex-ante identical, horizontal merger incentives under yardstick competition are generally aligned with social and consumer welfare. However, in most potential applications, natural monopoly operators are fairly heterogeneous. In Belgium, for instance, the most efficient electricity distribution system operators of 2010 spent twice as much for the same level of service as the industry's least productive firms (Agrell and Teusch, 2015), and such heterogeneity is expected to increase fur-

[19] Note, however, that merger effects are also affected by the distribution of production possibilities across firms. If all firms are identical, there cannot be welfare losses under either regime. But the two regimes differ with respect to which firms matter. Under A all outsiders matter in principle and perverse incentives are a possibility for all merger combinations where insiders are *ex-ante* more efficient than outsiders (Proposition 4.5). Under B, the effect size only depends on cost differences between Firm 1 and Firm 2. The more similar (different) the two firms' production possibilities are, the smaller (larger) the potential for welfare losses.

ther with the energy transition and the associated decentralisation of electricity production (Haney and Pollitt, 2013).

Heterogeneity would not necessarily pose a problem if the firms' production possibilities were constant over time as the regulator could then use historical cost information, e.g. by relying on sequential data envelopment analysis (Tulkens and Eeckaut, 2006) or rate freezes. Yet, changing service requirements of natural monopoly providers imply the need for technological innovation. In electricity distribution, to return to our topical example, the rise of distributed energy resources and the roll-out of electric vehicles may require new network infrastructures as well as 'vehicle-to-grid' services (Jenkins and Pérez-Arriaga, 2017). More generally, climate change appears to increasingly cause extreme weather events that infrastructure operators were not exposed to in the past; and socio-economic change makes consumers demand higher quality services, e.g. fewer supply interruptions or cleaner products. Relying on historical cost information alone is thus rarely feasible in regulatory practice.

In the special case of best-practice regulation, an unstable frontier (i.e. changing peers) may prevent firms from gaming the system. If the regulator, for instance, does not correct the firms' costs for expenses incurred due to weather events beyond the operator's control, frontier firms can be expected to vary year by year in a way hard to predict for the industry. While an unstable frontier has the advantage of preventing firms from gaming the system by seeking out frontier firms for strategic mergers or collusive agreements, it is hardly a desirable feature in sectors such as electricity or water which require predictability to attract long-term investments (Cronin and Motluk, 2007a).

Due to these real-world constraints, avoiding incentive distortions altogether will thus often not be feasible and they indeed occur under yardstick regulation, e.g. in Norwegian electricity distribution (Agrell et al., 2015). Against this background, our research provides some guidance as to how the right choice of the yardstick regime can help keep distortions at bay. When the regulator is in charge of an industry with a large number of independent (and comparable) firms, average-cost yardstick competition has the advantage that incentive distortions are small if the number of insiders relative to the industry size is small. The intuition is that the influence of a merger on the regulated revenue is counterbalanced by the many independent firms in the industry, whose costs also inform the insiders' prices. In industries with many peers, firms would thus

need to consolidate a large part of the industry to substantially raise prices. Because of transaction costs this may be challenging to organise in practice which should provide a safeguard against socially harmful mergers. Under best-practice regulation, by contrast, firms could face perverse incentives to merge horizontally even in industries with many independent firms. The reason is that any firm's revenue allowance only depends on a small subset of firms (one in our model) which can more easily be manipulated through mergers.

In smaller industries with few potential peers, on the other hand, best-practice regulation may trump average-cost yardstick regimes. This is because the former avoids the issue of perverse incentives (and the need for merger control) for most potential mergers. The competition authority could then focus on the subset of merger proposals that involve peer firms and veto efficiency-decreasing mergers (even though this is informationally challenging to assess). In addition, we showed that missing incentives cannot occur under best-practice regulation. By contrast, firms may refrain from proposing efficiency-increasing mergers in average-cost yardstick regimes. Given that firms are in this case also compared to relatively inefficient firms, peer firms that are less efficient than their reference set will be deterred from proposing welfare-increasing mergers (unless they are compensated by sufficient efficiency gains) because merging would make their reference set more efficient.

The article has also highlighted the issue of distributional merger effects. Mergers under yardstick competition do not only affect the insiders' profit, but additionally impact consumers as well as producers in other parts of the country. Interregional cleavages between consumers may create political economy obstacles and raise equity concerns, potentially requiring regulatory remedies. This is because consumers in outsider regions benefit from efficiency-increasing mergers, whereas those living in merged areas may face higher prices. In addition, the external effect mergers with efficiency gains impose on outsiders may imply that cost targets after yardstick mergers could become infeasible for the outsiders.

This provides a theoretical justification for regulatory practices geared toward avoiding firm bankruptcy and ensuring that at least some of the merger gains are shared with local consumers. We have discussed one such mechanism, basing part of a firm's allowed revenue on its own observed costs. Another measure that performs a similar function is to establish minimum and maxi-

mum rates of return on capital (Edvardsen et al., 2006). The drawback of these mechanisms is, however, that they may prevent (some) firms from cost minimisation. Comparing the potential incentive distortions created by these different regulatory remedies would appear an important avenue for future research.

References

Agrell, Per J., Peter Bogetoft, and Thor Erik Grammeltvedt (2015), "The efficiency of the regulation for horizontal mergers among electricity distribution operators in Norway." *Proceedings of 12th International Conference on the European Energy Market*, 1–5.

Agrell, Per J and Emili Grifell-Tatjé (2016), "A dynamic model for firm-level response to non- credible regulation." *Energy Policy*, 90, 287–299.

Agrell, Per J. and Jonas Teusch (2015), "Making the Belgian distribution system fit for the energy transition. The case for yardstick competition." *Reflets et perspectives de la vie économique*, 2015, 157–174.

Armstrong, Mark and David EM Sappington (2007), "Recent developments in the theory of regulation." *Handbook of Industrial Organization*, 3, 1557–1700.

Auriol, Emmanuelle and Jean-Jacques Laffont (1992), "Regulation by duopoly." *Journal of Economics & Management Strategy*, 1, 507–533.

Averch, Harvey and Leland L Johnson (1962), "Behavior of the firm under regulatory constraint." *The American Economic Review*, 1052–1069.

Beesley, Michael E and Stephen C Littlechild (1989), "The regulation of privatized monopolies in the United Kingdom." *The RAND Journal of Economics*, 454–472.

Belleflamme, Paul and Martin Peitz (2015), *Industrial Organization: Markets and Strategies*. Cambridge University Press.

Bogetoft, Peter and Lars Otto (2011), *Benchmarking with DEA, SFA, and R. International Series in Operations Research & Management Science*, volume 157. Springer.

Crémer, Jacques and Richard P McLean (1985), "Optimal selling strategies under uncertainty for a discriminating monopolist when demands are interdependent." *Econometrica: Journal of the Econometric Society*, 53, 345–361.

Crew, Michael A and Paul R Kleindorfer (2002), "Regulatory economics: Twenty years of progress?" *Journal of Regulatory Economics*, 21, 5–22.

Cronin, Francis J and Stephen A Motluk (2007a), "Flawed competition policies: designing 'Markets' with biased costs and efficiency benchmarks." *Review of Industrial Organization*, 31, 43–67.

Cronin, Frank J and Stephen A Motluk (2007b), "How effective are M&As in distribution? Evaluating the government's policy of using mergers and amalgamations to drive efficiencies into Ontario's LDCs." *The Electricity Journal*, 20, 60–68.

Dalen, Dag Morten (1998), "Yardstick competition and investment incentives." *Journal of Economics & Management Strategy*, 7, 105–126.

Danish Energy Regulatory Authority (2015), "2015 national report to the European Commission Denmark."

Demsetz, Harold (1968), "Why regulate utilities?" *Journal of Law and Economics*, 55–65.

Demski, Joel S, David EM Sappington, and Pablo T Spiller (1988), "Incentive schemes with multiple agents and bankruptcy constraints." *Journal of Economic Theory*, 44, 156–167.

Dijkstra, Peter T, Marco A Haan, and Machiel Mulder (2014), *Industry structure and collusion with uniform yardstick competition: theory and experiments.* University of Groningen, Faculty of Economics and Busisness.

Edvardsen, Dag Fjeld, Finn R Førsund, Wiljar Hansen, Sverre AC Kittelsen, and Thor Neurauter (2006), *Productivity and regulatory reform of Norwegian electricity distribution utilities*, 97–131. Edward Elgar Cheltenham.

European Commission (2004), "Guidelines on the assessment of horizontal mergers under the Council Regulation on the control of concentrations between undertakings." *Official Journal of the European Union*, 2004/C 31/03.

European Commission (2010a), "Case no COMP/M.5707 - TENNET/ E.ON." EUR-Lex document number 32010M5707.

European Commission (2010b), "Case no COMP/M.5827 - ELIA/ IFM/ 50HERTZ." EUR-Lex document number 32010M5827.

Farrell, Joseph and Carl Shapiro (1990), "Horizontal mergers: an equilibrium analysis." *The American Economic Review*, 107–126.

Fiocco, Raffaele and Dongyu Guo (2015), "Mergers between regulated firms with unknown efficiency gains." *Review of Economic Design*, 19, 299–326.

Greene, William (2005), "Reconsidering heterogeneity in panel data estimators of the stochastic frontier model." *Journal of Econometrics*, 126, 269–303.

Grossman, Sanford J and Oliver D Hart (1986), "The costs and benefits of ownership: A theory of vertical and lateral integration." *The Journal of Political Economy*, 691–719.

Gugler, Klaus, Dennis C Mueller, B Burcin Yurtoglu, and Christine Zulehner (2003), "The effects of mergers: an international comparison." *International Journal of Industrial Organization*, 21, 625–653.

Haney, Aoife Brophy and Michael G Pollitt (2013), "International benchmarking of electricity transmission by regulators: A contrast between theory and practice?" *Energy Policy*, 62, 267–281.

Jamasb, Tooraj, Paul Nillesen, and Michael Pollitt (2004), "Strategic behaviour under regulatory benchmarking." *Energy Economics*, 26, 825–843.

Jamasb, Tooraj and Michael Pollitt (2003), "International benchmarking and regulation: an application to European electricity distribution utilities." *Energy Policy*, 31, 1609–1622.

Jamasb, Tooraj and Michael Pollitt (2008), "Reference models and incentive regulation of electricity distribution networks: An evaluation of sweden's network performance assessment model (npam)." *Energy Policy*, 36, 1788–1801.

Jenkins, Jesse D. and Ignacio J. Pérez-Arriaga (2017), "Improved regulatory approaches for the remuneration of electricity distribution utilities with high penetrations of distributed energy resources." *The Energy Journal*, 38.

Joskow, Paul L (2013), "Incentive regulation in theory and practice: electricity distribution and transmission networks." In *Economic Regulation and Its Reform: What Have We Learned?*, University of Chicago Press.

Kumbhakar, Subal C and Lennart Hjalmarsson (1998), "Relative performance of public and private ownership under yardstick competition: electricity retail distribution." *European Economic Review*, 42, 97–122.

Kwoka, John and Michael Pollitt (2010), "Do mergers improve efficiency? Evidence from restructuring the US electric power sector." *International Journal of Industrial Organization*, 28, 645–656.

Laffont, Jean-Jacques and David Martimort (2000), "Mechanism design with collusion and correlation." *Econometrica*, 68, 309–342.

Laffont, Jean Jacques and Jean Tirole (1993), *A theory of incentives in procurement and regulation*. MIT press.

Lockwood, Ben (1995), "Multi-firm regulation without lump-sum taxes." *Journal of Public Economics*, 56, 31–53.

Lyon, Thomas P (1996), "A model of sliding-scale regulation." *Journal of Regulatory Economics*, 9, 227–247.

Macher, Jeffrey T, John W Mayo, and Jack A Nickerson (2011), "Regulator heterogeneity and endogenous efforts to close the information asymmetry gap." *Journal of Law and Economics*, 54, 25–54.

McAfee, R Preston and John McMillan (1995), "Organizational diseconomies of scale." *Journal of Economics & Management Strategy*, 4, 399–426.

Meran, Georg and Christian von Hirschhausen (2009), "A modified yardstick competition mechanism." *Journal of Regulatory Economics*, 35, 223–245.

Motta, Massimo (2004), *Competition policy: theory and practice*. Cambridge University Press.

Neeman, Zvika (2004), "The relevance of private information in mechanism design." *Journal of Economic Theory*, 117, 55–77.

Ofwat (2015), "Ofwats approach to mergers and statement of methods."

Oxera (2016), "Water company mergers: further developments in the pipeline?" *Agenda January 2016*, 1–4.

Roeller, Lars-Hendrik, Johan Stennek, and Frank Verboven (2006), "Efficiency gains from mergers."

Schmalensee, Richard (1989), "Good regulatory regimes." *The RAND Journal of Economics*, 417–436.

Schmid, Andreas and Marco Varkevisser (2016), "Hospital merger control in germany, the netherlands and england: Experiences and challenges." *Health Policy*, 120, 16–25.

Shleifer, Andrei (1985), "A theory of yardstick competition." *The RAND Journal of Economics*, 319–327.

Sobel, Joel (1999), "A reexamination of yardstick competition." *Journal of Economics & Management Strategy*, 8, 33–60.

Tangerås, Thomas P (2002), "Collusion-proof yardstick competition." *Journal of Public Economics*, 83, 231–254.

Tulkens, Henry and Philippe Vanden Eeckaut (2006), "Nonparametric efficiency, progress and regress measures for panel data: methodological aspects." In *Public goods, environmental externalities and fiscal competition*, 395–429, Springer.

Wallsten, Scott and Katrina Kosec (2008), "The effects of ownership and benchmark competition: An empirical analysis of US water systems." *International Journal of Industrial Organization*, 26, 186–205.