On regulation and competition: pros and cons of a diversified monopolist*

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This version: September 2011

Abstract

We study the regulation of a firm which supplies a regulated service while also operating in a competitive, unregulated sector. If the firm conducts its activities in the two markets jointly, it enjoys economies of scope whose size is the firm's private information, unknown either to the regulator or to the rival firms. We characterize the unregulated market outcome (with price and quantity competition) and optimal regulation that involves an informational externality to the competitors.

Although joint conduct of the activities generates scope economies, it also entails private information, so that regulation is less efficient and the unregulated market too may be adversely affected. Nevertheless, we show that allowing the firm to integrate productions is (socially) desirable, unless joint production is characterized by dis-economies of scope.

Keywords: Regulation, Competition, Asymmetric Information, Conglomerate firms, Multi-utility, Scope economies, Informational externality.

Journal of Economic Literature Classification Numbers: L51, L43, L52.

*We thank Vincenzo Denicolò, David Martimort, John Panzar, Salvatore Piccolo, Wilfried Sand-Zantman, Jean Tirole. This paper builds on a thorough revision of a previous paper "Regulating a multi-utility firm" for whom we thank participants at the 2005 Conference in tribute to J-J. Laffont, the Conference on Public Services and Management 2006 in Toulouse, the EARIE Conference in Porto 2005, EEA Conference in Milan 2008, and seminar participants at CSEF in Anacapri, Boston College, IMT, and at the Universities of Evry, New South Wales, Padua, Paris I, Queensland and Venice. We also thank E. Bacchiega for research assistance.

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1 Introduction

Should a regulated firm be allowed to operate in a market open to competition and, if this is the case, how should regulation account for the interactions with competitive activities? These are central questions in market design of practical and theoretical relevance, and that have been at the center of an intense policy debate since at least three decades. They have been first addressed with respect to cases in which the competitive market is vertically related to the regulated one, as this can lead to distortions in the downstream competition, and even to market foreclosure. More recently, as a consequence of both important technological advancements and intense deregulation, the issue of regulation and competition has mainly involved horizontally related markets. In many cases regulated companies see, and try to exploit, opportunities of expanding their business into neighbouring markets, which are open to competition. In this paper we ask whether the concern that regulators of many countries show about horizontal diversification by a regulated monopolist is justified by the theoretical analysis and we investigate the interactions between activities in regulated and unregulated markets.

Examples of this industrial development now abound. For instance, although in principle in most EU countries all customers are free to buy electricity or gas in the free market, only a minority does, while most customers prefer to be protected by a regulated price. Therefore, most European local energy utilities (e.g. in Italy, Germany or Scandinavian countries) sell energy both to customers protected by regulated prices and to customers which can (and do) choose in the free market. In the same way, many regulated water companies also sell energy to free market customers. The French Veolia (very strong in regulated sectors such as water or environmental services) also generates electricity to be sold in the wholesale French market. More extreme examples can be found looking at Centrica in the UK, which operates both in gas and electricity transmission but which also claims to be the UK's leading drain-cleaning service firm (through the brand name Dyno). GDF-Suez in France and other countries, RWE in Germany, and Enel in Italy all operate in regulated as well as unregulated markets in energy, water and other utility sectors. In the US a major utility such as Pepco also offers energy management services. And so on...[1]

This horizontal diversification, leading to "conglomerate" firms, has raised substantial objections from regulatory institutions in the EU, in the US, as well as in other countries. These concerns have been motivated by the fear that diversification may imbalance competition in the unregulated sectors (a "level playing field" argument), and affect negatively consumers in the regulated markets

[1] This diversification is partly the consequence of utility de-regulation, taking place at different pace in different sectors, some of which have already been deregulated and liberalized, whilst others remain heavily regulated.

due to the increased complexity of the regulatory task.[2] On the side of the firms, there are several reasons for regulated firms to expand and diversify into unregulated markets.[3] However, the most commonly cited motivation goes under the heading "synergy", the buzz-word indicating economies of scope in the joint production and supply of horizontally diversified services.

In this paper we then take this double pronged perspective and study how increased complexity in regulation, due to joint production of horizontally differentiated activities, interacts both with regulation and the competitive market outcome. In particular, complexity is here represented by the common observation that the actual amount of cost savings (i.e. the synergy) is generally unknown both to the regulator and to the competitors in unregulated markets, and it is instead private information of the conglomerate performing joint production. Indeed, the lack of information concerning the actual size of cost synergies is often lamented both by regulators and competing firms in terms of reduced market transparency: they may suffer a very substantial asymmetry of information. This has recently moved policy makers, regulators and the academia towards an intense empirical research aiming to measure the actual magnitude of scope economies in multi-product firms with an outcome that can be summarized with the words of the EU Directorate-General of Energy and Transport in 2004 stating that the extent of separation "can only be decided on a case by case basis".[4] Although scope (and scale) economies are often found in empirical analyses, there is a significant variation due to unobserved heterogeneity which leaves open the aforementioned issue of asymmetric information: as reported in Panzar (2009), some regulators are led to argue that "the only way to ensure a level playing field is to prohibit incumbent firms that enjoy either de facto or de jure monopoly power in one market from participating in related competitive markets".

We explicitly take this issue of complexity and asymmetric information in conglomerate firms

[2] In the EU several Directives referring to utility services have stated that firms in regulated sectors that want to operate in competitive sectors as well must "unbundle", i.e. separate the assets and the personnel of the two sectors. The unbundling may be of several types. The Directives require at least separate accounts and sometimes separate companies which may or may not belong to different shareholders.

[3] For example, a multi-market strategy may facilitate collusion. Or regulated activities may leave some free-cash flow that managers invest in unregulated sectors so they can then operate aggressively in those markets or just because they are "empire builders".

[4] In a joint document issued by British sectorial utility regulators (OFWAT, 1998), it is stated that for regulators, external auditors, as well as for rival firms, measuring scope economies is complex and often inconclusive, especially when conducted before integration takes place. Other interesting reports are those commissioned again by OFWAT in 2004 and the Cave 2009 Independent review of competition and innovation in water markets, commissioned by the UK government. For empirical analysis on scope economies in transport, gas, electricity, water and other utility services see Farsi et al. (2007), Farsi et al. (2008), Fraquelli, et al. (2004), Piacenza and Vannoni (2004), Abbott and Cohen (2009), Marques (2010). These works, although interesting and based on improving empirical methods and better data, do not allow to reach clear cut conclusions. Walter et al. (2009) and Saal et al. (2011) are meta-studies offering a very heterogeneous picture. Also event studies of abnormal stock returns of mergers in horizontally differentiated sectors are inconclusive as for scope economies (see Berry, 2000 and Leggio and Lien, 2000).

that affects both regulations and competitors in unregulated markets. We then assess the trade-off between the potential benefits and costs of integrated (or joint) productions in these firms. To this end we first study how a conglomerate operates in both a regulated and an unregulated sector, with the magnitude of scope economies being the private information of the conglomerate when it is allowed to "bundle" its productions.[5] In this respect, the regulatory process and the conglomerate's choices in the regulated market (e.g. the regulated price) may reveal important information to competitors about the costs of the conglomerate. In other terms, the game in the unregulated market may or may not be one of asymmetric information, depending on the information generated by the regulatory process; this in turn affects the conglomerate's behavior in its regulated market, i.e. its incentive to disclose information to the regulator.

The effects of this informational externality from the regulated to the unregulated market depend on what type of competition takes place in the unregulated market. When firms compete in quantities, the regulator can more easily elicit information on scope economies, reducing distortions in the regulated sector. Acting as if economies of scope were small so as to obtain lenient regulation, the conglomerate would get the countervailing effect of inducing the rival firms to expand in the unregulated market. With price competition, by contrast, the informational externality complicates the regulatory process since behaving as if scope economies were small prompts an accommodating reaction by the rivals in the unregulated market. The regulator may thus be forced to apply a uniform regulatory policy (regardless of the actual size of the scope economies) so that no information is disclosed to rivals. Information is not the only channel connecting regulated and unregulated markets since a larger regulated output *per-se* (i.e. independently of the actual and believed scope economies) implies smaller costs in the unregulated market for the conglomerate. This firm thus prefers a larger regulated output (a "top dog" strategy) under strategic substitutability in the unregulated market, as with quantity competition, and a lower regulated output (a "puppy dog" strategy) under strategic complementarity, as with price competition.

We then move on comparing welfare when the conglomerate is allowed to run joint productions for the two markets with that with compulsory separation preventing a firm from exploiting its economies of scope for the sake of transparency. On the one hand, if economies of scope are substantial, consumers in the two markets may benefit from the gain in efficiency. On the other hand, since scope economies is the private information of the conglomerate, the lack of information for the regulator and competitors affects and, as shown, it may distort the regulated price and

[5] Our model can be also reinterpreted as one where consumers get higher utility from "one stop shop" (e.g. when joint billing lowers transaction costs): the cross-market effect goes through the utility function rather than economies of scope.

competition in the unregulated market.[6] We show that in our environment, even though horizontal integration causes transparency problems for regulation and for competitors, these adverse effects are smaller than the efficiency gains from integration. It is important to stress that the key to our result is not that the regulator is able to appropriate and internalize some of the efficiency generated by the joint production. Conglomerate integration increases the difficulty of the regulatory contract and may bring about negative spillover on the unregulated markets. The main point is that these issues – usually placed at the centre of the policy debate and used to justify the aforementioned institutional responses – are more than compensated by the greater efficiency of the firm. Letting the conglomerate integrate its operations is thus desirable in our model unless there are diseconomies of scope, a case where a conglomerate diversification may still be pursued if the managers are "empire builders".

The paper is organized as follows. We conclude this section with a literature review, and introduce the model in the next section. Section 3 analyzes benchmark cases, with full information and separation of activities. Section 4 derives optimal regulation when the conglomerate is allowed to integrate. Section 5 uses these results to study the welfare effects of integration in the case of quantity and of price competition. Section 6 discusses extensions and alternative modelling assumptions. Section 7 concludes. All the proofs are in the Appendix.

1.0.1 Related literature

The early literature on diversification of regulated firms into unregulated sectors has initially emphasized the risks and the costs of this practice and, in particular, the undesirable possibility that the diversified conglomerate diverts resources and profits from regulated core-markets to unregulated ones. Along these lines, early papers, such as Braeutigam and Panzar (1989), Brennan (1990), Brennan and Palmer (1994), questioned the desirability of horizontal diversification addressing the possibility of cross-subsidies *via* cost shifting, in which an integrated firm attributes to the regulated activity costs that actually pertain to non-regulated ones and thus obtains higher regulated prices, while at the same time behaving more aggressively in the unregulated sectors.[7] The trade-off about horizontal diversification has been emphasized also in another pertinent analysis by Sappington (2003), with a model where effort can be allocated to regulated and unregulated

[6] It is well known from the literature on information sharing in oligopolies (see Sakai 1985 and Vives 1999, Chapter 8, for a survey) that total welfare may be reduced when firms compete under asymmetric information.

[7] In our analysis the regulated service and unregulated service bear no vertical relationship, which is instead the case in Vickers (1995). In our paper, the regulated firm's rivals do not need to purchase the regulated good, but still are affected by the cost saving that the integrated firm enjoys by operating both services.

activities. Although the analysis of optimal regulated prices and competition in the unregulated market remains limited by modelling choice, Sappington offers an interesting discussion of optimal regulatory policy towards diversification that offers a different view than in our analysis. He shows that for diversification to be undesirable two conditions must hold at the same time: the regulator cannot control effort diversion and also the firm can inflate expenditures (by cost padding) on unregulated activities. These papers illustrate the potential risks of diversification in terms of cross-subsidies and effort diversion. Relative to this strand of literature, we also emphasize the increased complexity and lack of transparency that emerges when the regulated firm is allowed to diversify its activities in unregulated markets. Differently from these papers, we investigate this issue in terms of adverse selection within a modelling environment which is quite standard at least since Baron and Myerson (1982).

Lewis and Sappington (1989) study a model where the costs of regulated activities are positively correlated with profitability in the unregulated sector. Within this setting and with a black-boxed description of profitability in the competitive market, they show how "countervailing incentives" may affect regulation. A benefit of diversification is here that the regulator could learn something about the regulated firm's costs by observing its behavior in an unregulated market. Our analysis instead shows that this informational externality can be a "two-way street" in that when asymmetric information pertains the dimension of scope economies, the firm too can affect its rivals in the unregulated market that may obtain information observing actual regulation. Countervailing incentives have also been discussed also in Iossa (1999) who considers the design of a regulated two-product industry with interdependent and unknown demand. She shows that whether an integrated monopolist or two separate firms is desirable depends on the interplay between the demand complementarity/substitutability of the two products.

Our analysis differs from all these papers on several respects. We emphasize that integrated production is both a source of scope economies but also of private information for the conglomerate with respect to the regulators and its rivals. The informational issues arise exactly from joint production in that neither the regulator nor the rivals know the exact magnitude of scope economies, as previously clarified. Hence, our analysis provides a different perspective with respect to that on effort diversion in the previous papers. Explicitly describing the unregulated market we can properly study if and when the regulated firm might have an unfair advantage in that market and how the rivals react to the information generated by regulation itself.

This paper is also related to the large literature on information sharing in oligopoly (surveyed in Vives, 1999). Interestingly, in many of the real cases quoted above the rival firms often lament the lack of information about the actual scope economies of the regulated conglomerate. With this respect we illustrate how that the availability of information in a market does not necessarily come from firms' decisions but may also result from an information externality of "third parties" such as the regulator in our environment. The paper thus naturally brings together two strands of economic literature, one on regulation and another on information sharing, which had been considered independent since now. On a similar vein, since actual regulated output per-se affects the scope economies, we provide a similar bridge with the literature on strategic investment (see for example Fudenberg and Tirole (1984) and more recently Etro, 2006).

Finally, this paper also contributes to the contract theory literature by considering an environment in which (i) an agent (the conglomerate) has private information on how a contractible and a non contractible action interact in her payoff (respectively the regulated output and the firm's activity in the unregulated market); (ii) the optimal (regulatory) contract set by the principal at the same time screens the agent's type and signals this private information to third parties (i.e. the competitors in the unregulated market). This informational externality that plays such an important role in our analysis of regulated and unregulated markets also arises in different contexts. For example, Calzolari and Pavan (2006) study the optimal disclosure of information between two sellers who contract sequentially with the same privately-informed buyer, showing that the upstream seller may gain by disclosing information downstream when there are countervailing incentives or if the goods of the two sellers are substitutes.

2 Model Set-up

We consider a regulated natural monopoly (market R) and an unregulated oligopoly (market U). Demand functions in regulated and unregulated markets are independent, decreasing and (twice) differentiable. Inverse demand in the regulated market R is $p(q)$ where q is output. The unregulated market U consists of n firms indexed by $i = 1, ..., n$, each producing (possibly differentiated) output y_i with price p_i^U. Inverse demand functions are $p_i^U(y_i, Y_{-i})$ $i = 1, ..., n$, where Y_{-i} denotes the vector of the outputs of other firms. The vectors of prices and outputs in the unregulated market are denoted by p^U and Y respectively. Competition in the unregulated sector takes place either in quantities or in prices.

A "conglomerate" firm operates in both markets, respectively producing outputs q and y_1 (index $i = 1$ will denote the conglomerate firm in market U). This firm may be allowed to run productions in the two markets jointly (*integrated production*), or may be forced to organize productions in separate units (unbundling). In the latter case, *separating productions* makes impossible for the conglomerate to share assets and internal resources that may bring about cost savings. Formally, let $C(q, y_1; \theta)$ denote the total production cost of the conglomerate with joint production, where θ is a parameter discussed below. If instead separation is imposed, the conglomerate's total costs is $C(0, y_1; \theta) + C(q, 0; \theta)$. Joint production thus generates a cost saving corresponding to

$$C(0, y_1; \theta) + C(q, 0; \theta) - C(q, y_1; \theta) \geq 0, \tag{1}$$

which is nil when either $q = 0$ or $y_1 = 0$. The size of scope economies is parametrized by θ so that the expression in (1) is nil if $\theta = 0$ and, for any $\theta'' \geq \theta'$,

$$C\left(0, y_1; \theta''\right) + C\left(q, 0; \theta''\right) - C\left(q, y_1; \theta''\right) \geq C\left(0, y_1; \theta'\right) + C\left(q, 0; \theta'\right) - C\left(q, y_1; \theta'\right),$$

with $C\left(q, y_1; \theta''\right) = C\left(q, y_1; \theta'\right)$ if either $q = 0$ or $y_1 = 0$. Thus, the larger is θ the higher are scope economies and, if separation is imposed, θ has no bite on costs.[8] Assuming that the cost function is twice differentiable with respect to q and y_1, the previous conditions imply that (i) a larger output for one of the two markets induces a marginal cost reduction for the output in the other market, (ii) this cost reduction is larger the higher is θ (and vanishing when $\theta = 0$),

$$\frac{\partial^2 C(q, y_1; \theta'')}{\partial q \partial y_1} \leq \frac{\partial^2 C(q, y_1; \theta')}{\partial q \partial y_1} \leq 0, \text{ for any } \theta'' \geq \theta', \tag{2}$$

and (iii) a higher value of θ (weakly) reduces the marginal cost for both outputs,

$$\frac{\partial C(q, y_1; \theta'')}{\partial z} \leq \frac{\partial C(q, y_1; \theta')}{\partial z} \text{ for } z \in \{q, y_1\} \text{ and any } \theta'' \geq \theta'. \tag{3}$$

The following simple specification of the cost function, that we will use in some examples, satisfies all the previous properties,

$$C_1(q, y_1; \theta) = c(q + y_1) - \theta q y_1. \tag{4}$$

The technology available to all other firms in market U (i.e. firms with index $i = 2, ..., n$) is

[8] Economies of scope associated with fixed costs may well induce strategic effects in the unregulated market, as in our set up. In fact, with joint fixed costs F apportionment rules are very often used in practical regulations which are proportional to outputs (here q and y_1). Those rules would re-introduce variable-cost effects since the apportionment of F to product q, for example, would be $F \times q/(q + y_1)$. This possibility is explored in Calzolari (2001). Chaaban (2004) studies the effects of various cost-apportionment rules for a joint fixed cost that is privately known by the multi-utility.

simply $C(y_i) \equiv C(0, y_i; \theta)$ and profits are

$$\pi_i(y_i, Y_{-i}) \equiv y_i p_i^U(Y) - C(y_i). \tag{5}$$

When the firm is allowed to integrate production its *total* profit Π is (the apex I will stand for integration)

$$\Pi^I(q, y_1, Y_{-1}; \theta) \equiv qp(q) + y_1 p_1^U(Y) - C(q, y_1; \theta) - T, \tag{6}$$

where T is a tax/transfer which is part of the regulatory contract in market R (see below). On the contrary, if the conglomerate must keep apart its production for the two markets, its profit becomes $\Pi^S + \pi_1(y_1, Y_{-1})$ (the apex S will stand for separation) where

$$\Pi^S \equiv qp(q) - C(q, 0; \theta) - T. \tag{7}$$

The regulator maximizes social welfare W which is a weighted sum of net consumer surplus in the two markets, firms profits and taxes (or transfers). Let V_j denote gross consumer surplus in sector $j = R, U$. The welfare function then is

$$W = V_R(q) - qp(q) + V_U(Y) - Yp^U(Y) + T + \alpha(\Pi + \sum_{i=2}^{n} \pi_i), \tag{8}$$

where $Yp^U(Y) = \sum_{i=1}^{n} y_i p_i^U(Y)$ and the weight to profits is $\alpha < 1$.[9] The regulatory contract contemplates a quantity q (or equivalently a price p) and the transfer (T) to the firm. By definition of unregulated market U, the regulator cannot explicitly control output (of single firms or total output) in that market. Although in the US the idea that paying a transfer to privately owned companies sometimes clashes against institutional constraints, notice that in continental Europe local public transport monopolists are typically granted contracts which entail prices below costs as well as service obligations covered by public transfers. This happens in railways as well, and even in the US railways companies receive federal funds (net of taxes paid) of the order of magnitude of 1 bn US$ per year.[10]

[9] As usual we exclude that $\alpha = 1$ since in this case, equally valuing consumers surplus and profits, the regulator could simply entitle the firm all the surplus generated and then induce first best choices. Costly public funds are discussed in Section 6. We will not discuss the possibility that the regulator uses different weights to profits of regulated and unregulated firms. In a different context of regulation, this is analyzed by Calzolari and Scarpa (2009).

[10] See http://www.bts.gov/publications/federal_subsidies_to_passenger_transportation/. for subsidies to other modes of transport. Only in 1997 the Taxpayer Relief Act provided Amtrak with a tax credit in the amount of $2.18 billion in current dollars. Notice that these figures only refer to *federal* subsidies, while State subsides are harder to measure.

By directly operating joint production, a firm is able to realize much better than the regulator and the rival firms whether there are economies of scopes and, if so, their actual magnitude. Hence, the exact value of θ is private information of the conglomerate and neither the regulator, nor the competitors in the unregulated market know it. For simplicity, we assume there are no other pieces of private information. This is clearly a simplification as regulation of a standard single-product firm is also often affected by informational issues. We employ this assumption to single out the effects of asymmetric information explicitly related to economies of scope and to the complexity of conglomerates. The fact that private information pertains scope economies is a distinctive trait of our analysis that naturally link the regulated and unregulated market outcomes. It is common knowledge that scope economies can be either high or low, i.e. $\theta \in \Theta \equiv \{\underline{\theta}, \overline{\theta}\}$ with $\nu = \Pr(\theta = \bar{\theta}) = 1 - \Pr(\theta = \underline{\theta})$, $\overline{\theta} \geq \underline{\theta}$ and we rule out diseconomies of scope, i.e. $\underline{\theta} \geq 0$ (see the discussion in Section 7 on the possibility of diseconomies).[11]

The timing of the game is the following:

1. The regulator decides whether or not to impose separation of productions to the conglomerate firm, then accordingly sets and publicly announces the regulatory policy.

2. The firm learns the size of scope economies, i.e. its type θ, and then decides in which markets to operate. Regulation is enforced.

3. Finally, competition in the unregulated sector takes place.

Stage 2 indicates that the conglomerate is not obliged to participate the regulated market and will do so only if it finds it profitable. As we will discuss, if the firm wants to serve the regulated market, then it always prefers to bundle production in the two sectors, if allowed to do so. Finally, the timing also shows that the execution of a regulatory contract naturally anticipates the determination of the equilibrium in the competitive sector. Indeed, regulation follows procedures (such as regulatory lags that often last several years) and activities which are more complicated to modify than market decisions of private firms.

The exact magnitude of scope economies becomes clear to the conglomerate if it is allowed to integrate production and effectively does so. In this respect, we thus regard as impractical the possibility to condition the decision concerning joint or separate production on the realization of θ. This would require letting the conglomerate set up integrated production, learn θ and then

[11] The restriction to two types is only for ease of exposition, and an extension to a continuum of types would not qualitatively affect our results. The basic references for regulation under asymmetric information are Baron and Myerson (1982) and Laffont and Tirole (1986).

subsequently impose separation by splitting productions if scope economies turn out to be low. Therefore the regulator's decision on separation/integration cannot be made conditional on the specific regulatory policy and/or on the actual realization of θ.[12]

Notice that whether or not integration is allowed, the number of firms in the unregulated market is assumed to be constant, equal to n. If integration instead entailed a reduction in the number of firms (from n to $n-1$) active in U, then we would have a "trivial" anti-competitive effect of integration.

3 Efficient regulation

In this section we introduce two benchmarks which will help to discuss the pros and cons of joint production in the presence of asymmetric information. We first analyze the case where separation of productions is imposed, and then we study the case with joint productions and full information.

Optimal regulation with separate productions Since asymmetric information matters only in case of joint production, the regulated firm's profit in sector R with separation is simply as in (7). Let firm i's *equilibrium* output in sector U be defined as y^S which depends neither on θ nor on q and the associated profits $\pi^S \equiv \pi_i\left(y_i^S, Y_{-i}^S\right) \geq 0$. The regulator then maximizes (8) with respect to q and T, subject to the participation constraint of the regulated firm, which assures that the conglomerate wants to serve (also) the regulated market, i.e. $\Pi^S + \pi^S \geq \pi^S$. Welfare can be written as follows

$$W^S = V_R(q) + V_U(Y^S) - C\left[q, 0; \theta\right] - \sum_{i=1} C(y^S) - (1-\alpha)(\Pi^S + \sum_{i=1} \pi^S)$$

which shows that, as usual, distributive efficiency would require to reduce as much as possible firms' profits in the two markets. The regulator then optimally sets the transfer at a level T^S so that the participation constraint binds and the conglomerate earns no additional profits with respect to π^S, i.e. $\Pi^S = 0$. Furthermore, the optimal regulated quantity q^S is set efficiently so that the price in the regulated sector is equal to the marginal cost, i.e. $p(q^S) = \partial C(q^S, 0; \theta)/\partial q$. For future reference we indicate with $\mathcal{C}^S \equiv (q^S, T^S)$ this optimal regulatory policy when separation is imposed and with $W^S(\mathcal{C}^S)$ the associated social welfare.

[12] In the sequel we will nevertheless illustrate that even if one considers this possibility, no qualitative changes would emerge on our main results.

Joint productions and full information Assume now that the conglomerate is allowed to integrate productions and that the public authority and the rivals are fully informed on scope economies θ. Consider a generic strategic variable x_i for firm i in market U so that $x_i = p_i$ if competition takes place in prices and $x_i = y_i$ for quantity competition. The following system of first order conditions

$$\frac{\partial \Pi^I(x_1, X_{-1}, q; \theta)}{\partial x_1} = 0, \ \frac{\partial \pi_i(x_i, X_{-i})}{\partial x_i} = 0, \text{ for } i = 2, ..., n$$

yields the market equilibrium in sector U.[13] For the sake of convenience, in the following we express profits as functions of equilibrium output levels $y_1(q,\theta)$, $y_i(q,\theta)$ $i = 2, ..., n$:

$$\pi_i^I(q,\theta) = \pi_i\left[y_i(q,\theta), Y_{-i}(q,\theta)\right], \text{ for } i = 2, ..., n$$
$$\Pi^I(q,\theta) = \Pi^I\left[q, y_1(q,\theta), Y_{-1}(q,\theta); \theta\right],$$

and similarly for welfare,

$$\begin{aligned} W^I(q, Y(q,\theta), \theta) = \quad & V_R(q) + V_U\left[Y(q,\theta)\right] - C\left[q, y_1(q,\theta); \theta\right] - \sum_{i \neq 1} C\left[y_i(q,\theta)\right] + \\ & -(1-\alpha)[\Pi^I(q,\theta) + \sum_{i \neq 1} \pi_i^I(q,\theta)]. \end{aligned} \tag{9}$$

Anticipating outputs in market U and for a given (and known) θ, the regulator maximizes (9) subject to the conglomerate's participation constraint

$$\Pi^I(q,\theta) \geq Max\{\pi^S, \Pi^S\} = \pi^S$$

where $\Pi^S = 0$ as shown above. Knowing θ, the regulator sets the transfer T such that the participation constraint binds for any θ and no extra-profits are given to the conglomerate, i.e. $\Pi^I(q,\theta) = \pi^S$. Maximizing (9) with respect to q for any θ, the optimal regulated quantity with full information and integration $q_{FI}^I(\theta)$ is such that

$$p(q_{FI}^I(\theta)) = SMC[q_{FI}^I(\theta), \theta] \tag{10}$$

[13] We assume that the conditions for an interior unique equilibrium are met.

where the right hand side is the *social marginal cost* of q, i.e.

$$\begin{aligned} SMC\left[q,\theta\right] \equiv & \tfrac{\partial C[q,y_1(q,\theta);\theta]}{\partial q}+ \\ & -\left(p_1^U-\tfrac{\partial C[q,y_1(q,\theta);\theta]}{\partial y_1}\right)\tfrac{\partial y_1(q,\theta)}{\partial q}-\sum_{i\neq 1}^{n}\left(p_i^U-\tfrac{\partial C[y_i(q,\theta)]}{\partial y_i}\right)\tfrac{\partial y_i(q,\theta)}{\partial q}+ \\ & +(1-\alpha)\sum_{i\neq 1}^{n}\tfrac{\partial \pi_i^I(q,\theta)}{\partial q}. \end{aligned} \quad (11)$$

The optimality condition (10) shows that the price differs from the simple marginal cost $\partial C/\partial q$ (the first line in (11)) for two reasons. Since q affects firms' decisions in the unregulated market, the regulator internalizes the effect of q on distortions in market U due to market power. This is illustrated in the second line of SMC where the price-cost margin for each firm are weighted by the impact that q has on each firm's equilibrium output in that sector (i.e. $\partial y_1\left(q,\theta\right)/\partial q\geq 0$ and $\partial y_i\left(q,\theta\right)/\partial q\leq 0$ for $i\neq 1$).[14] The third line in (11) indicates an additional reason to give up standard allocative efficiency in the regulated market, now due to a distributional concern. By inducing the regulated firm to produce more in market R, the regulator reduces the profits of other firms in the unregulated market (since $\partial \pi_i^I/\partial q\leq 0$), thus increasing social welfare through enhanced distributive efficiency. Although these effects may be possibly conflicting (contrary to all other terms, inducing rivals to expand their outputs requires a reduction of q), integration tends to expand regulated output so that $\overline{q}_{FI}^I\geq \underline{q}_{FI}^I\geq q^S$, as illustrated in the explicit model of in Section 4.1.[15]

We will indicate with $\mathcal{C}_{FI}^I=\left\{q_{FI}^I\left(\theta\right),T_{FI}^I\left(\theta\right)\right\}_{\theta\in\Theta}$ the optimal regulatory contract with integrated production and full information and with $W_{FI}^I=E_\theta[W^I(\mathcal{C}_{FI}^I,\theta)]$ the associated welfare.

4 Regulation of a privately informed conglomerate

Let us now consider a conglomerate allowed to jointly run productions but also privately informed on the level of scope economies θ. We can rely on the Revelation Principle so that for the case of integration the regulator designs a menu of type-dependent contracts $\mathcal{C}=\left\{\left(q\left(\theta\right),T\left(\theta\right)\right)\right\}_{\theta\in\Theta}$ which maximizes the (expected) social welfare and induces the conglomerate to announce the true level of scope economies to the regulator. By so doing, a conglomerate with scope economies θ selects

[14] This departure from marginal cost pricing is typical in the literature on mixed oligopolies (see for example De Fraja and Delbono, 1990), where the firm under public control distorts its choices to boost the efficiency of private firms.

[15] If the regulator were only concerned by welfare in market R, regulated quantities would be smaller but still larger than q^S due to economies of scope.

the policy $(q(\hat{\theta}), T(\hat{\theta}))$ by announcing $\hat{\theta} = \theta$.[16]

The contract of the regulator here screens firm's type and at the same time signals it to the competitors. This possibility in mechanism design has been studied by the literature on sequential contracting with multiple principals which has shown under what conditions one can rely on the Revelation Principle and direct mechanisms when the same informed agent (the firm in our model) contracts first with an upstream principal (here the regulator) and subsequently interacts with downstream principals.[17] Our environment is however simpler since the firm at the second stage does not contract with other principals but simply competes with its rivals in market U and, adapting the results of this literature, the restriction to direct mechanisms is here without loss of generality.

As a matter of fact, unregulated firms in sector U do not observe communication between the conglomerate and the regulator (i.e. the announcement $\hat{\theta}$). However, the implemented regulatory policy $q(\hat{\theta}), T(\hat{\theta})$ is clearly public information (for example, each consumer observes the regulated price on her own bill), so that, knowing the regulatory policy $\mathcal{C}$, rival firms obtain information on θ by simply observing the (implemented) regulated price $\widehat{p}$ or, equivalently, the quantity $\widehat{q}$ (in the sequel we will indicate updating with respect to $\widehat{q}$). This is an important *informational externality* of regulation which allows competitors to update their beliefs about the level of the scope economies and then accordingly set their strategic variables in the unregulated market. It is important to realize also that this informational externality in turn affects the regulated firm's incentives to report $\hat{\theta}$, as we discuss next.

Given the (truthful) announcement of economies of scope, the competitive market game may or may not be one of complete information. More precisely, if optimal regulation is *discriminatory* (as with a "screening" contract) with different quantities and prices for different announcements $\widehat{\theta}$, the updating process is then perfect so that $v(\widehat{q}) \equiv \Pr(\overline{\theta}|\widehat{q}) = 1$ when $\widehat{q} = q(\overline{\theta})$ and $v(\widehat{q}) = 0$ when

[16] Acting before competition takes place in market U, the regulator cannot infer any information on θ by observing firms' activities in that market.

[17] Indeed, Calzolari and Pavan (2006, 2009) and Pavan and Calzolari (2008) show that the issues with direct mechanisms may realize for two reasons. First, when upstream allocations are observable (but not the upstream mechanism), direct mechanisms may fail to characterize all equilibrium outcomes (in particular those sustained by non-Markov strategies) since downstream players may be precluded to hold different beliefs on the mechanism used upstream (by the regulator) in case they observe out-of-equilibrium allocations. However, this is not an issue in our environment since the regulatory mechanism is naturally observable. A second issue may emerge due exactly to the observability of upstream mechanisms since payoff-irrelevant distinctions among mechanisms, that are not available with direct mechanisms, can be used as correlation devices for the principals' decisions. However, this is again not an issue here since we are considering pure strategy equilibria. With this respect Strausz (2006) has shown that also in standard static environments with a single principal, not allowing randomizations (as it is the case most of the principal-agent papers) may preclude characterization of all equilibrium allocations with direct mechanisms. Finally, since y_1 is a moral hazard variable for the regulator, the appropriate reference for the application of direct mechanisms is here the Generalized Revelation Principle of Myerson (1982).

$\widehat{q} = q(\underline{\theta})$. On the other hand, if regulation is *uniform* (as with a "pooling" or bunching contract), the regulated quantity $\widehat{q}$ does not depend on the firm's type and the competitors are not able to perform any updating so that $v(\widehat{q}) = v$.[18]

Given $\widehat{q}$, we can then illustrate the Bayesian (continuation) equilibrium in the unregulated market in which the strategic variables (either prices or quantities) satisfy the following set of necessary conditions,

$$\frac{\partial}{\partial x_i} E_\theta \left[\pi_i(x_i, X_{-i}) | \widehat{q} \right] = 0, \text{ for } i = 2, ..., n$$
$$\frac{\partial}{\partial x_1} \Pi^I(\widehat{q}, x_1, X_{-1}; \theta) = 0, \text{ for } \theta \in \Theta$$

where $E_\theta \left[\pi_i(x_i, X_{-i}) | \widehat{q} \right]$ is the rivals' expected profit (with expectation over θ), conditional on the information provided by $\widehat{q}$. We denote with $y_1 \left(\widehat{q}, \theta, v(\widehat{q}) \right)$ the equilibrium output in the competitive market for a conglomerate with (true) scope economies θ, producing a regulated output $\widehat{q}$ and when the rival firms' updated beliefs are $v(\widehat{q})$. Similarly, let $y \left(\widehat{q}, v(\widehat{q}) \right)$ be the rivals' output which clearly does not depend on the *true* level of scope economies but only on observed quality $\widehat{q}$ and associated $\widehat{\theta}$. Consistently with our notation, we will denote with $y_1 \left(\widehat{q}, \theta, 1 \right), y_1 \left(\widehat{q}, \theta, 0 \right)$ and $y \left(\widehat{q}, 1 \right), y \left(\widehat{q}, 0 \right)$ outputs of a type θ conglomerate and of its rivals when they believe that the true level of scope economies are either $\overline{\theta}$ or $\underline{\theta}$.

Since the regulator is uninformed on the level of scope economies, she must design a regulatory contract that induces truthful revelation by any type θ.[19] Consider a conglomerate with scope economies θ which declares $\widehat{\theta}$ and gets the contract $(\widehat{q}, \widehat{T}) \in \mathcal{C}$. This firm obtains a profit,

$$\Pi^I(\widehat{\theta}, \theta) \equiv \widehat{q}\, p(\widehat{q}) + y_1 \left(\widehat{q}, \theta, v(\widehat{q}) \right) \; p_1^U \left[y_1 \left(\widehat{q}, \theta, v(\widehat{q}) \right), Y_{-1} \left(\widehat{q}, v(\widehat{q}) \right) \right] + \\ - C \left[\widehat{q}, y_1 \left(\widehat{q}, \theta, v(\widehat{q}) \right); \theta \right] - \widehat{T}.$$

On the other hand, by truthfully announcing its scope economies this firm obtains a profit $\Pi^I(\theta) \equiv \Pi^I(\widehat{\theta}, \theta)$ with $\widehat{\theta} = \theta$. Hence, any type of firm θ will truthfully announce the level of scope economies if

$$\Pi^I(\theta) \geq \Pi^I \left(\widehat{\theta}; \theta \right) \quad \forall \widehat{\theta} \in \Theta.$$

This incentive compatibility constraint for type θ can be conveniently rewritten as follows. Let $\Pi_U \left(\widehat{q}, \theta, v(\widehat{q}) \right)$ be the profit earned in the unregulated market U by the conglomerate with (true)

[18] Few comments are in order on rivals' updating. We implicitly assume that the multi-utility cannot credibly communicate θ to the rivals. Entry in sector R is uninformative since regulation induces entry by any type θ, as discussed below. Finally, we do not consider the possibility that the regulator could "fine tune" information disclosed to the unregulated market. This would require a stochastic regulatory contract that we will discuss in Section 7.

[19] The Revelation Principle may be invalid if the announcement $\widehat{\theta}$ had a direct effect on firm's payoff. This is however not the case since $\widehat{\theta}$ only indirectly affects rivals' beliefs $v(\widehat{q})$ through the regulator's instruments $(q(\widehat{\theta}), T(\widehat{\theta}))$.

scope economies θ, producing $\widehat{q}$ in sector R and inducing the rivals to believe that scope economies are $\widehat{\theta}$, i.e.

$$\begin{aligned} \Pi_U\left(\widehat{q},\theta,v(\widehat{q})\right) &\equiv y_1\left(\widehat{q},\theta,v(\widehat{q})\right)\ p_1^U\left[y_1\left(\widehat{q},\theta,v(\widehat{q})\right),Y_{-1}\left(\widehat{q},v(\widehat{q})\right)\right]+ \\ &-\left\{C\left[\widehat{q},y_1\left(\widehat{q},\theta,v(\widehat{q})\right);\theta\right]-C\left[\widehat{q},0;\theta\right]\right\} \end{aligned} \tag{12}$$

where the costs attributed to unregulated production is simply the *incremental cost* of y_1.[20] Then, truthful revelation is guaranteed by the following equivalent condition

$$\Pi^I\left(\theta\right)\geq\Pi^I(\widehat{\theta})+\Pi_U\left(\widehat{q},\theta,v(\widehat{q})\right)-\Pi_U(\widehat{q},\widehat{\theta},v(\widehat{q})),\text{ with }\widehat{\theta}\neq\theta.$$

In particular, the conglomerate with high scope economies $\overline{\theta}$ prefers not to mimic the one with small scope economies $\underline{\theta}$ and vice-versa if

$$\begin{aligned} &\overline{\Pi}^I\geq\underline{\Pi}^I+\Delta_\theta\Pi_U\left(\underline{q},v(\underline{q})\right) \qquad IC(\overline{\theta}) \\ &\underline{\Pi}^I+\Delta_\theta\Pi_U\left(\overline{q},v(\overline{q})\right)\geq\overline{\Pi}^I \qquad IC(\underline{\theta}) \end{aligned} \tag{13}$$

where

$$\Delta_\theta\Pi_U\left(q,v(q)\right)\equiv\Pi_U\left(q,\overline{\theta},v(q)\right)-\Pi_U\left(q,\underline{\theta},v(q)\right)$$

identifies the extra gain that type $\overline{\theta}$ obtains with respect to $\underline{\theta}$ when they both produce the same regulated output q and induce beliefs $v(q)$ on the rivals.

The scope economies announcement $\widehat{\theta}$ has here several interesting effects. First, as in standard models of regulation with asymmetric information, more efficient firms have incentives to understate their level of scope economies and to mimic less efficient firms in order to obtain more lenient and favorable regulation. This *cost-efficiency effect* of the announcement is captured in the term $\Delta_\theta\Pi_U\left(\underline{q},v(\underline{q})\right)$ by the difference $-[C\left(\underline{q},y_1;\overline{\theta}\right)-C\left(\underline{q},y_1;\underline{\theta}\right)]\geq 0$. Indeed, if the efficient firm with type $\overline{\theta}$ mimics type $\underline{\theta}$, it produces the same regulated quantity $\underline{q}$ with a cost saving corresponding the previous cost difference.

On the other hand, the presence of an unregulated market generates two additional effects of the announcement. A *direct strategic effect* emerges since rival firms observe the regulated output and they know that, because of property (2), if $\widehat{q}$ is large, their cost disadvantage (with respect to the conglomerate) is also large independently of the actual θ. We also have a *beliefs-driven strategic effect* which is the consequence of asymmetric information in market U and would not exist if rivals knew θ. Indeed, observing $\widehat{q}$ the rivals may be induced to believe that scope economies are either

[20] Being $C[\widehat{q},0;\widehat{\theta}]=C\left[\widehat{q},0;\theta\right]$, the cost in Π_U can be indeed written in terms of incremental costs as in (12).

large or low depending on $\widehat{\theta}$, whatever the true level of scope economies is. Hence, the incentive for the conglomerate to declare its type also depends on the reaction of its rivals which is driven by these two strategic effects (direct and belief-driven), as we will further illustrate.

Anticipating all these effects, the regulator then sets the optimal regulatory policy $\mathcal{C}^*$ maximizing the expected social welfare subject to the incentive compatibility constraints $IC(\theta)$ as in (13) and the participation constraints

$$\Pi^I(\theta) \geq \pi^S \qquad \forall\theta \in \Theta \quad IR(\theta).$$

In the Appendix we show how to deal with these constraints, illustrating that participation of the efficient firm is guaranteed, that the inefficient firm is granted nothing more than its outside option, and that $IC(\overline{\theta})$ binds at the optimum. On the other hand, whether incentive compatibility for the inefficient firm (re-written as in (16) below) is relevant and affects optimal regulation depends on properties of the regulated and unregulated market.

This leads to the following result.

Proposition 1 (Optimal regulation) *Let $\tilde{q}(\theta)$ be defined for any $\theta \in \Theta$ by*

$$p\left(\tilde{q}(\theta)\right) = SMC\left(\tilde{q}(\theta), \theta\right) + \mathcal{I}(\theta)(1-\alpha)\frac{v}{1-v}\frac{\partial \Delta_\theta \Pi_U\left(\tilde{q}\left(\theta\right), 0\right)}{\partial q}, \tag{14}$$

with the indicator function $\mathcal{I}(\theta) = 1$ if $\theta = \underline{\theta}$. Let also the constant $\tilde{q}$ be defined by

$$p\left(\tilde{q}\right) = E_\theta[SMC\left(\tilde{q}, \theta\right) + (1-\alpha)\frac{v}{1-v}\frac{\partial \Delta_\theta \Pi_U\left(\tilde{q}, v\right)}{\partial q}]. \tag{15}$$

*(i) Optimal regulated quantity $q^*(\theta)$ is **discriminatory** with $q^*(\theta) = \tilde{q}(\theta)$ if $\tilde{q}(\theta)$ is such that*

$$\Delta_\theta \Pi_U\left(\tilde{q}(\overline{\theta}), 1\right) \geq \Delta_\theta \Pi_U\left(\tilde{q}(\underline{\theta}), 0\right), \tag{16}$$

*otherwise it is **uniform** with $q^*(\theta) = \tilde{q}$.*

(ii) The profit of a conglomerate with scope economies θ is

$$\Pi^I(\theta) = \pi^S + (1 - \mathcal{I}(\theta))\Delta_\theta \Pi_U\left(\underline{q}^*, v\left(\underline{q}^*\right)\right)$$

with $\underline{q}^*$ as in point (i).

To interpret the results in the Proposition assume for the moment that constraint (16) is always satisfied so that optimal quantities are discriminatory. Then, as in standard models of regulation with asymmetric information, the regulator must guarantee the conglomerate with large scope economies (i.e. type $\overline{\theta}$) an additional rent $\Delta_\theta \Pi_U(\underline{q}, v(\underline{q}))$ which corresponds to the higher profit type $\overline{\theta}$ could obtain with respect to $\underline{\theta}$ when asked to produce the same quantity $\underline{q}$ and rivals believe that scope economies are low (i.e. constraint $IC(\overline{\theta})$ binds at the optimum). The (socially costly) rent of type $\overline{\theta}$ is an increasing function of the quantity designed for low scope economies (i.e. $\partial \Delta_\theta \Pi_U(\underline{q}, 0)/\partial \underline{q} \geq 0$), so that the optimal $\underline{q}$ is distorted downwards relative to full information, and we (generically) have $q^*(\overline{\theta}) > q^*(\underline{\theta})$ (which justifies the rivals' beliefs described above). If the conglomerate's incentives to announce the level of scope economies were solely driven by the cost efficiency effect, then this monotonicity on regulated output would also guarantee that the inefficient conglomerate (i.e. type $\underline{\theta}$) had no incentives to mimic type $\overline{\theta}$ since, otherwise, it would have to produce a large output $q^*(\overline{\theta})$ which is too costly given its low efficiency.

However, we know that incentives to announce the level of scope economies are here also affected by the two strategic effects which may either facilitate or hinder the regulatory process. Now, the role of the two strategic effects is best understood rewriting the incentive compatibility constraint for type $\underline{\theta}$ as follows,

$$\Pi_U\left(\overline{q}, \overline{\theta}, 1\right) - \Pi_U\left(\underline{q}, \overline{\theta}, 0\right) \geq \Pi_U\left(\overline{q}, \underline{\theta}, 1\right) - \Pi_U\left(\underline{q}, \underline{\theta}, 0\right). \tag{17}$$

which corresponds to (16) in the Proposition.[21] The left hand side is the change of profits in market U for a type $\overline{\theta}$ conglomerate when regulated quantity is $\overline{q}$ and rivals consequently believe scope economies are $\overline{\theta}$, as compared to profits with quantity $\underline{q}$ and rivals believing $\underline{\theta}$. Similarly, the right hand side is the same profit difference for a type $\underline{\theta}$ conglomerate.[22]

With *quantity competition* in the unregulated market (i.e. strategic substitutability), a firm which appears to be more efficient induces its rivals' to behave less aggressively, thus reducing their outputs and increasing its profits. If $\overline{q} \geq \underline{q}$, then shifting regulated production from $\underline{q}$ to $\overline{q}$ induces a contraction of the rivals' outputs (for any given θ and associated beliefs) because of the direct strategic effect. Similarly, for the beliefs-strategic effect, declaring large scope economies induces the rivals to revise their beliefs and again contract their outputs. Both these changes account for an *increase* of profits Π_U so that both sides of (17) become larger for the two strategic effects on

[21] Substituting $\overline{\Pi}^I = \underline{\Pi}^I + \Delta_\theta \Pi_U(\underline{q}, v(\underline{q}))$ (since $IC(\overline{\theta})$ binds at the optimum as shown in the Appendix) and $\underline{\Pi}^I = \pi^S$ (since $IR(\underline{\theta})$ also binds), constraint $IC(\underline{\theta})$ becomes $\underline{\Pi}^I = \pi^S \geq \pi^S + \Delta_\theta \Pi_U(\underline{q}, v(\underline{q})) - \Delta_\theta \Pi_U\left(\overline{q}, v(\overline{q})\right)$ which is equivalent to (17) and (16).

[22] If only the cost-efficiency effect were at play, (17) would reduce to $C\left(\overline{q}, y_1; \overline{\theta}\right) - C\left(\overline{q}, y_1; \underline{\theta}\right) \geq C(\underline{q}, y_1; \overline{\theta}) - C(\underline{q}, y_1; \underline{\theta})$ which is satisfied by $\overline{q} \geq \underline{q}$ for properties (2)-(3) of the cost function.

the unregulated market. Furthermore, since higher scope economies amplify any change on profits Π_U, the two effects make the left hand side larger than the right hand side, thus making the overall mimicking (potential) gain for type $\underline{\theta}$ even less attractive. In other terms, incentive compatibility for the inefficient firm is less demanding than without the two strategic effects and the regulated output may be incentive compatible even if standard monotonicity $\overline{q} \geq \underline{q}$ is violated, thus relaxing the regulatory program.

If instead, the unregulated market is characterized by *price competition* (i.e. strategic complementarity), both the two strategic effects have adverse consequences on regulation. In fact, the conglomerate induces an accommodating response of its rivals if it now shifts from production $\overline{q}$ to $\underline{q}$ so that the two strategic effects reduce both sides in (17). Since these changes are intensified by higher scope economies, the left hand side decreases more than the right hand side and the two effects make more difficult to satisfy incentive compatibility for type $\underline{\theta}$. A consequence is that, contrary to standard models of regulation with asymmetric information, constraint $IC(\underline{\theta})$ may be violated even if regulated output is monotone and, if this is the case, the regulator may be obliged to give up discriminating with respect to scope-economies, thus resorting to uniform regulation as indicated in the pricing condition (15).

The two strategic effects are also relevant for the firm's rent $\Delta_\theta \Pi_U(\underline{q}, v(\underline{q}))$ illustrated in Proposition 1. It is now clear that the informational rent $\Delta_\theta \Pi_U$ of the efficient conglomerate is larger if mimicking an inefficient firm induces the rivals to believe that it is really inefficient, i.e. when $v(\underline{q}) = 0$. On the contrary, if the rivals were informed on the level of scope economies, so that their beliefs would be $v(\underline{q}) = 1$ in any case, then they would reduce their price by much lesser extent than when their beliefs are $v(\underline{q}) = 0$ so that, ultimately, the rent would be smaller, i.e. $\Delta_\theta \Pi_U(\underline{q}, 1) \leq \Delta_\theta \Pi_U(\underline{q}, 0)$. It now should also be clear that the direct strategic effect similarly increases the firm's rent with price competition and that, conversely, the two strategic effects reduce the rent when firms compete on quantities.

These results are summarized in the following Proposition.

Proposition 2 (Regulation with quantity and price competition) .

(i) With ***quantity-competition*** *in the unregulated market, optimal regulation is discriminatory with* $\underline{q}^* = \tilde{q}(\underline{\theta}) \leq \underline{q}^I_{FI}$, $\overline{q}^* = \tilde{q}(\overline{\theta}) = \overline{q}^I_{FI}$. *The conglomerate earns lower profits due to the lack of information on scope economies of the rival firms and the direct strategic effect in the unregulated market.*

(ii) With ***price-competition****, optimal regulation may be either discriminatory with* $q^*(\theta) = \tilde{q}(\theta)$ *or uniform with* $q^*(\theta) = \tilde{q}$ *for any* θ *and* $\underline{q}^I_{FI} \gtrless \tilde{q} \leq \overline{q}^I_{FI}$. *In any case, the conglomerate earns larger*

profits due to the lack of information of the rivals and the direct strategic effect in the unregulated market.

The discussion above highlights how different forms of market competition have different consequences on the ability of the regulator to design an efficient regulatory contract. With Cournot competition, eliciting information from the regulated firm is easier, so that the regulatory contract benefits from the existence of a competitive market, where the conglomerate can freely operate. The opposite holds under price competition, where revealing a firm's efficiency may stimulate the rivals' reaction.

These different effects and the role played by the unregulated market in the regulatory process will prove important also for the analysis in Section 5 in which we will investigate the desirability of joint or separate productions. Before turning to this analysis it is instructive to present a simple model which allows to explicitly investigate the interplay between the regulated and unregulated activities of the conglomerate.

4.1 An explicit model

Let costs be described by (4) so that the level of scope economies is simply assessed by the term $-\theta q y_1$ in the cost function and consider the following demands,

$$\begin{array}{ll} \text{Market } R: & p_R = \mu_R - q, \text{ (with } \mu_R \geq c \text{)} \\ \text{Market } U: & \begin{cases} p_i^U = \mu - y_i - \sum_{j \neq i} \gamma y_j & \text{with quantity competition} \\ y_i = m - b p_i^U + \sum\limits_{j \notin i} s p_j^U & \text{with price-competition} \end{cases} \end{array} \tag{18}$$

where m and μ are both larger than c, $b \geq (n-1)s \geq 0$ and s and γ are both positive and represent the substitutability parameter in the two environments.[23]

When the conglomerate cannot integrate productions, regulation in market R takes place under full information, with optimal price $p(q^S) = c$ and quantity $q^S = \mu_R - c$ and the conglomerate is left with profit π^S which depends on the type of competition in the unregulated markets. The regulatory contract in this case is $\mathcal{C}^S \equiv (\mu_R - c, -\pi^S)$.

Quantity-competition. Imagine the conglomerate with true scope economies θ chooses a regu-

[23] This systems of demand for market U are derived from utility $V_U [y_1, y] = \mu (y_1 + (n-1)y) - \frac{1}{2} \left(y_1^2 + (n-1)y^2\right) - \gamma[(n-1)y_1 y + (n-1)(n-2)y^2]$ and in the case of price-competition $m = \frac{\mu}{\gamma(n-1)+1}$, $b = \frac{\gamma(n-2)+1}{(1-\gamma)(\gamma(n-1)+1)}$, $s = \frac{\gamma}{(1-\gamma)(\gamma(n-1)+1)}$. The expressions and results discussed in this subsection are explicitely derived in the online Appendix available at http://www2.dse.unibo.it/calzolari/web/papers.html.

lated output $\widehat{q}$ (by announcing $\widehat{\theta}$). The quantities in market U can then be written as follows

$$\begin{aligned} y_1\left(\hat{q}, \theta, v\left(\hat{q}\right)\right) &= y_1^{FI} + \tfrac{1}{2(2-\gamma)(2+(n-1)\gamma)}\left[2(2+(n-2)\gamma)\theta\Delta\hat{q} + (n-1)\gamma^2\widehat{q}\Delta\hat{\theta}\right] \\ y\left(\widehat{q}, v(\widehat{q})\right) &= y^{FI} - \tfrac{\gamma}{(2-\gamma)(2+(n-1)\gamma)}[\theta\Delta\hat{q} + \widehat{q}\Delta\hat{\theta}] \end{aligned} \tag{19}$$

where $\Delta\hat{\theta} = \widehat{\theta} - \theta$ and $\Delta\hat{q} = \widehat{q} - q(\theta)$ and y_1^{FI} and y^{FI} are the outputs prevailing were the regulator and rivals all informed on θ.[24] The two terms related to $\Delta\hat{q}$ and $\Delta\hat{\theta}$ in the previous expressions respectively represent the direct and the beliefs-driven strategic effects previously discussed. Clearly when the conglomerates truthfully announces scope economies (so that $\Delta\hat{\theta} = 0$ and $\Delta\hat{q} = 0$), then quantities correspond to the full information ones. When the conglomerate instead overstates scope economies, i.e. when they are characterized by $\underline{\theta}$ but the firm announces $\overline{\theta}$, then since both expressions $\Delta\hat{\theta}$ and $\Delta\hat{q}$ are positive (the latter when monotonicity holds), the conglomerate expands its production and the rivals contract theirs. Hence, the conglomerate gains by overstating and the rivals lose in the unregulated market. The opposite holds by understating scope economies.

Constraint $IC(\underline{\theta})$ is here equivalent to

$$\frac{(\overline{\theta} - \underline{\theta})}{4(2-\gamma)(2+(n-1)\gamma)}\left[K \times (\overline{q} - \underline{q}) + H\right] \geq 0 \tag{20}$$

where K is always positive and $H \geq 0$ whenever monotonicity holds (i.e. $\overline{q} \geq \underline{q}$). Hence, with Cournot competition monotonicity is indeed *sufficient* for incentive compatibility of type $\underline{\theta}$, as previously discussed. Furthermore and along the same lines, the conglomerate's rent $\Delta_\theta \Pi_U(\underline{q}, 0)$ is reduced by rivals' imperfect information when the conglomerate understates scope economies.

Price-competition. When the conglomerate with real scope economies θ announces a type $\widehat{\theta}$, so that the regulator implements a regulated quantity $\widehat{q}$ and rivals' priors become $v(\widehat{q})$, then the prices in market U become

$$\begin{aligned} p_1^U\left(\widehat{q}, \theta, v(\widehat{q})\right) &= p_1^{FI} - \tfrac{1}{2(2b+s)(2b-(n-1)s)}\left[2b(2b-(n-1)s)\theta\Delta\hat{q} + (n-1)s^2\widehat{q}\Delta\hat{\theta}\right] \\ p^U\left(\widehat{q}, v(\widehat{q})\right) &= p^{FI} - \tfrac{bs}{(2b+s)(2b-(n-1)s)}[\theta\Delta\hat{q} + \widehat{q}\Delta\hat{\theta}] \end{aligned} \tag{21}$$

Now, contrary to quantity competition, if rivals expect economies of scope larger than real ones (i.e. $\Delta\hat{q} \geq 0$, $\Delta\hat{\theta} \geq 0$), then they reduce their price and, by complementarity, the conglomerate also reduces its price. The conglomerate's profit Π_U in market U is thus decreasing in $\Delta\hat{q}$ and $\Delta\hat{\theta}$.

[24] We will concentrate on parameters configurations which guarantee that second order conditions are met, both in quantity and price competition. For outputs in market U these conditions are immediately met (notice that y_1 is chosen for given q) and the marginal cost of q is always decreasing in the explicit model since $\partial^2 y_1/\partial q^2 = 0$.

As previously explained, the conglomerate's incentives to understate scope economies are strengthened when competition in the unregulated market revolves around prices, so that the regulator will find it more difficult to obtain information revelation. This reflects into the constraint $IC(\underline{\theta})$ which is here equivalent to (20) with the difference that now $H \leq 0$ whenever monotonicity holds which implies that monotonicity is here *necessary but not sufficient* for $IC(\underline{\theta})$ to hold. We also have that the firm's rent $\Delta_\theta \Pi_U(\underline{q}, 0)$ is reduced by rivals' imperfect information when the conglomerate overstates scope economies. With numerical investigation (reported in the online Appendix) we can show that uniform regulation is more likely to take place the larger is the number n of competitors, the smaller are the degree of substitutability γ and the maximum level of scope economies $\overline{\theta}$. These results have intuitive explanations. The inefficient conglomerate will find it appealing to mimic the efficient one (so that pooling becomes optimal for the regulator) when the two types are not too different, since otherwise the standard cost-efficiency effect prevails thus making mimicking unprofitable. This is also the case when there are many competitors, so that the overall strategic effect is large and every rival firm will react less to the announcement that the conglomerate is efficient and, similarly, when the goods are poor substitutes, as when γ is large, imitating the more efficient type would trigger a tough reaction by the competitors.

The explicit model also allows us to derive some interesting results on how the intensity of competition affects the conglomerate firm's rent. Recall that market U is characterized by a sub-optimal output level, which the regulator can affect by reducing the cost of the conglomerate in market U, thus making it more aggressive. This matters, first of all, as for the substitutability between the goods. When the products in the U market are closer substitutes, the regulator's decision on regulated output, by determining the conglomerate's marginal cost in the U market, has a stronger effect on unregulated prices. This is reflected into regulated quantities and consequently also y_1 and p_1 that increase in γ. But then, since the conglomerate's rent is increasing in $\underline{q}$, stronger substitutes may lead to larger rent. Therefore, independently of the type of competition, more substitutable products in market U (*i.e.* larger γ) may also increase the informational rent.

As for the number of competitors, things differ depending on the type of competition. In general, notice that the larger is n the less distorted market U is, so that the regulator's interest in affecting the market is reduced. Hence, in this respect the regulated quantity should be increased to account for market power in U only to a lesser extent. With quantity competition, the two strategic effects induce the firm to produce more, and this effect is stronger the higher the number of competitors. Therefore, a more competitive unregulated market *a fortiori* induces a lower rent, which is the standard effect one would normally expect.

However, things are less straightforward with price competition, so much that the conglomerate's informational rent may be higher when the unregulated market is less concentrated. We know that with price competition a more competitive market U the two strategic effects are stronger and indeed the conglomerate's rent is increasing in n for given $\underline{q}$. When this second effect prevails (which requires that n is not too large and that the profit at stake in market U is large, i.e. that the demand intercept μ is large), then the overall effect of a larger n can be that the conglomerate's rent increases.

Hence, if a regulated firm were to choose, it may well prefer to expand into a more competitive unregulated market.

5 The desirability of horizontal integration

Let us now come to the main question mark, i.e. whether allowing the conglomerate to integrate production of regulated and unregulated outputs is desirable at all. In other words, we study the desirability of allowing a regulated firm to expand its activities into an unregulated and competitive market.

To analyze the desirability of integration and its pros and cons, it is first useful to illustrate (as a benchmark) the simpler case in which the regulator is fully informed. When the conglomerate can integrate its activities and there is *full information*, several effects emerge on welfare relative to the case of separation. First, the conglomerate is more efficient in its activities in the unregulated market where total industry costs are then lower, and so are equilibrium prices. Second, the overall profits earned by the firms in the two industries are reduced. In fact, total profits earned by the firms in the two markets are $\pi^S + \sum_{i \neq 1} \pi_i^I (q, \theta)$ with integration and $\sum_{i=1}^n \pi_i^S$ with separation and we know that $\pi_i^I (q, \theta) \leq \pi_i^S$ since with integration the rivals face a tougher competitor. Hence, with full information allowing integrated conglomerate production is clearly desirable. Notice that a similar result would emerge *even if the rivals were not informed* on θ, as regulation would convey all the information on θ to the rivals. Indeed, (generically) we would have regulated outputs $\overline{q}_{FI}^I \neq \underline{q}_{FI}^I$ and prices $\overline{p}_{FI}^I \neq \underline{p}_{FI}^I$. Hence, again joint production would be preferable to separation.[25]

We can summarize these preliminary findings stating that if the regulator is fully informed on scope-economies, letting the conglomerate to integrate its productions is socially desirable. This discussion points out that the problem with joint production should possibly relate to the worsening

[25] The desirability of integration would hold in this case even if optimal regulation conveyed only partial information on θ to the unregulated market. In fact, welfare associated with full disclosure is always attainable and larger than that with separation, as discussed in the text.

of the *regulator's information*. Indeed, when this is the case, none of the previous arguments is sufficient to reach a conclusion on the desirability of integration. Nevertheless we can state the following general result.

Proposition 3 (Desirability of Integration) *Irrespective of the type of competition in the unregulated market, letting the regulated firm integrate and run joint production for regulated and unregulated markets is socially desirable, even if both the rival firms and the regulator do not know the value of scope economies.*

The result for the case of price competition in market U is relatively simple to derive. We have seen that a potential problem with price competition is the information revelation process which may well lead to large distortions on regulated outputs. Indeed, the conglomerate has additional incentives to lie to the regulator, hiding its efficiency. Because of strategic complementarity, if the rivals perceive that the conglomerate is more efficient they will react more aggressively. As a consequence, inducing the regulated firm to reveal its type is more difficult, and regulation becomes less efficient. Hence a trade-off emerges: the greater technical efficiency which comes from integration entails a larger distortion in the regulated price and a larger informational rent for the conglomerate. However, consider the contract $\mathcal{C}^S$ which the regulator optimally designs for the case of separation. Applying this policy when the conglomerate instead integrates production raises a potential problem: with this contract, uninformed rivals would end up with no information on the magnitude of scope economies. However, with price competition (in general with strategic complementarity) the possibility that the regulated firm has lower costs makes *rivals more aggressive* even if they do not know exactly the magnitude of scope economies, thus inducing a larger welfare in the unregulated market. Hence, although regulation $\mathcal{C}^S$ is suboptimal and leaves the rivals uninformed, with price competition it still allows to reach a larger welfare than with separate productions, thus making joint productions even more desirable when an optimal regulatory contract is in place.

Consider now quantity competition in the unregulated market. One cannot rely on the same reasoning using the contract designed for separation $\mathcal{C}^S$ as done above because with quantity competition leaving the rivals with no information may hurt the unregulated market. When the rivals do not know the value of θ and do not receive any information from the regulatory process (as it is the case when contract $\mathcal{C}^S$ is the policy in place), they act as if the conglomerate had an "average" level of scope economies. In particular, when the real value of θ is $\overline{\theta}$, rivals underestimate scope economies and produce more than they would otherwise do. On the contrary, when they overestimate the level of scope economies, they reduce production and it may well happen that the contraction of total production of the $n-1$ rivals exceeds the expansion of conglomerate's output.[26] Now, contract $\mathcal{C}^S$ may then induce the following ranking for total output in the unregulated market $Y\left(q^S,\overline{\theta},v\right) \geq Y^S \geq Y\left(q^S,\underline{\theta},v\right)$ and, since gross consumer surplus is a concave function of total output, the net effect of integration on (expected) consumer surplus in the unregulated market may be negative.

Hence, the different strategy of proof with quantity competition goes as follows. Temporarily consider a fictional environment in which the regulator is uninformed whilst the rivals are fully informed on θ and let us indicate the associated optimal policy with $\mathcal{C}'$. Imagine now to employ regulation $\mathcal{C}'$ when rivals do not know θ as in our model. It follows that $\mathcal{C}'$ (although sub-optimal in this case) remains incentive compatible. To see this (the formal proof is in the Appendix), recall our discussion in Section 4 showing that, when the rivals are uniformed and firms compete on quantities, the regulator will find it easier to elicit information by the conglomerate. In fact, the firm with large scope economies obtains a smaller profit and, at the same time, the inefficient firm finds it less convenient to mimic high scope economies when the rivals are uninformed. All this implies that even if regulation $\mathcal{C}'$ is designed for the case in which rivals are informed, with quantity competition in the unregulated market it remains incentive compatible also when applied to the case in which rivals are uninformed. Hence, although this policy $\mathcal{C}'$ is potentially suboptimal in the latter case, it induces truthful revelation and, what is more, it allows to reach a social welfare that is not smaller than that arising when the rivals do know the level of conglomerate' scope economies.

As a last step of the proof one then is left to show that in the informational environment in which the regulator does not know the level of scope economies but the rivals are fully informed on θ, then integration is socially desirable. With this result (briefly discussed in note and formally proved in the Appendix) we can conclude that by applying the contract $\mathcal{C}'$ in the environment of our model the regulator guarantees a surplus that, although not necessarily maximal, is still larger than that with separation and this concludes the proof.[27]

Hence, despite the asymmetric information on the level of scope economies that integration brings about, and irrespective of strategic complementarity or substitutability in the unregulated

[26] In the explicit model of Section 4.1 this is the case when $Y^S - Y(q^S,\underline{\theta},v) = (n-1)v\overline{q}\overline{\theta} - \underline{q}\underline{\theta}\left[2+v(n-1)\right]$ is positive, e.g. when $\underline{\theta}$ is sufficiently low. Furthermore, this uncertainty over θ may even induce some rivals to exit the market, although this is not explicitly considered in the model.

[27] Consider the informational environment in which the regulator does not know θ but the rivals are fully informed. By employing contract $\mathcal{C}^S$ and allowing integrated production the regulator increases the welfare. Indeed, the consumer surplus in R would be unaffected; the conglomerate would obtain a larger profit due to scope economies which increase welfare proportionally to the weight α (T^S is also clearly unchanged); finally, being the rivals fully informed, the unregulated market simply becomes more efficient because one of the active firms (the conglomerate) now has lower costs.

market, integration is preferable to separation: the reaction of competition in the unregulated market can be ultimately turned to the benefits of consumers in the two markets and overall welfare.[28]

6 Extensions

Our analysis is based on some specific assumptions which are not necessary to our results. In this section we can show how we can generalize the model in different directions.

Cost of public funds. Raising funds from the taxpayer may be costly due to distortionary taxation. The regulation literature has contemplated this possibility introducing a shadow cost of public funds λ such that each dollar transferred to/from the firm values $1+\lambda$ to society with $\lambda \in [0,1]$.[29] It has been shown that (see Armstrong and Sappington, 2007) standard models of regulation with costly public funds are qualitatively equivalent to models in which the regulator weights firms' profit less than consumers' surplus (i.e. $\alpha < 1$, as in the previous pages). However, it is here interesting to see whether the presence of the unregulated market has any additional role with this respect. With standard substitutions, the social welfare in case of integration becomes

$$\begin{aligned} W &= V_R(q) + V_U(Y) - C[q, y_1(q,\theta);\theta] - \sum_{i \neq 1} C[y_i(q,\theta)] - (1+\lambda-\alpha)\Pi - (1-\alpha)\sum_{i=2}^{n} \pi_i + \\ &\quad + \lambda\{qp(q) + y_1 p^U(Y) - C[q, y_1(q,\theta);\theta]\} \end{aligned}$$

We have then two types of effects with respect to the model illustrated in the previous pages with $\lambda = 0$. First, the informational rent Π now clearly costs more to the regulator since any dollar the regulator has to leave to the conglomerate in terms of rents has now the additional cost of the associated distortionary taxation. Whether regulation is discriminatory or uniform would not be affected, whilst the exact regulated quantity would be further distorted since the weight to the distortionary term (see the pricing rules (14) and (15)) becomes $1+\lambda-\alpha$. The second line in the previous expression for W illustrates the second effect. Since a larger profit (net of transfer) to the regulated firm allows one to reduce T and thus distortionary taxation, the regulator has now

[28] As stated in Section 2, it is impractical to first let the firm integrate and then split it apart. Furthermore, although one might conceive a contract, where the decision to integrate is taken by the Government, conditional on the observed level of scope economies, even in that (probably implausible) situation our result that separation is dominated by allowing integration would anyway hold with similar arguments. The general principle of unbundling, often considered by regulatory authorities, is thus a dominated policy.

[29] This may be the consequence of inefficiencies in the use of public funds, distortionary taxation or alternative use of the funds for public goods.

a further incentive to favor the regulated firm against its competitors. In a standard model of regulation the second line in W would simply induce a Ramsey pricing rule. In our environment, the optimal regulated price would be affected by this novel effect since indeed the regulator would like to boost profitability of the conglomerate in market U thus increasing Π_U (see the definition (12)).

Although the proof on the desirability of integration in the previous section are not affected by the cost of public funds, this second effect clearly makes the payoff of integration even larger.[30] Therefore, our main conclusions about the desirability of integration would be strengthened.

Diseconomies of scope. In our model we have assumed that integration brings about an efficiency gain (namely, that $\theta > 0$). However, in general we cannot exclude that integration may lead to diseconomies of scope if the two markets are not sufficiently close, to really allow the firm to exploit synergies. The interesting possibility would be modeled in our environment by assuming that now the "low type" is now associated with diseconomies of scope, i.e. $\underline{\theta} < 0$. It is simple to observe first that the derivation of optimal regulation is unaffected by this possibility. Our reasoning about incentive compatibility is unaffected (the high type still wants to mimic the low type, which in turn may be a fortiori induced to mimic the high type with price competition). Of course, we would have that the optimal regulated quantity for the low type $\underline{q}$ would be now smaller than that with separation since by doing so the regulator can reduce the conglomerate's rent as usual and also the market power distortion in the unregulated market.

As for the desirability of integration of the conglomerate's activities, our previous result would be instead affect. Indeed, one possible drawback of integration would be the risk of a conglomerate less efficient than with separation. On the other hand, for the same reasons illustrated in our previous discussion, the firm may still want to integrate since this gives the firm an informational advantage *vis à vis* the regulator. This simple observation may thus deliver a possible explanation of managers' desire to build their own inefficient "empires" which, *prima facie*, may be difficult to rationalize.

Endogenous number of competitors. Interestingly, our analysis could also be extended over a long run horizon with free entry. Indeed, in this case the zero-profit condition (for rival firms) would make our arguments even simpler. Without going into analytic details, one may consider that with zero profits in the unregulated market what counts is really consumer surplus,

[30] In our model information disclosure to the rivals would not be affected since whether regulation is discriminatory or uniform does not depend on λ. However, a model with fine tuning of information (on this see the discussion in the concluding section) would show how the information actually disclosed depends on λ.

so that allowing integration has a more straightforward impact on price and hence on welfare. In case production in the unregulated market entails a fixed cost, notice moreover that integration would also reduce the duplication effect noted by Vickers (1995) in a slightly different set-up, where vertical integration is considered.

The participation constraint. We have assumed that the regulator must grant the conglomerate firm a total profit, which is not smaller than the one the firm can obtain in the unregulated market when deciding not to participate in the regulated market R, i.e. $\Pi^I(\theta) \geq \pi^S$. In other terms, participating also the regulated market cannot generate a loss to the conglomerate firm since the regulator cannot extract any of the profits that the conglomerate would have obtained by being active in the unregulated market alone. Hence, the conglomerate firm's participation constraint we have considered is standard but in the current framework has features, which are worth discussing.

If the regulated firm does integrate its activities with those in the unregulated market, two elements lead to increase its profits (also) in this market. The first one is the cost reduction due to the economies of scope and naturally pertains to both activities since scope economies are, by definition, not attributable to a single one. The fact that the regulator is given the right to "tax" it away within the regulatory contract could be questioned, but also defended. A different apportionment of scope economies in which the conglomerate firm fully appropriates it is not defendable.

The second element is more subtle and pertains the effect of expanding output in the unregulated market which is generated again by the efficiency increase of scope economies. From an "ex ante" perspective the associated profit increase is uniquely due to integration and scope economies because without integration this change in profit would not have been available to the firm. However, "ex post" it may be accounted for as part of the profits attributable to the unregulated market where the conglomerate ultimately produces $y_1(q(\theta), \theta, v(q(\theta)))$ and the rivals $Y_{-1}(q(\theta), v(q(\theta)))$. Now, one could consider the following profit in market U induced by those outputs (still excluding scope economies from costs):

$$\Pi_U^I(q(\theta), \theta, v(q(\theta))) \equiv y_1(q(\theta), \theta, v(q(\theta)))\; p_1^U[y_1(q(\theta), \theta, v(q(\theta))), Y_{-1}(q(\theta), v(q(\theta)))] - C[0, y_1(q(\theta), \theta, v(q(\theta)))$$

Hence, the regulator could grant the conglomerate at least this profit, thus adding to the set of constraints of our regulatory program in Section 4 also the following one, for any θ

$$\Pi^I(\theta) \geq \Pi_U^I(q(\theta), \theta, v(q(\theta))).$$

Now we can further develop our analysis in the previous pages. With price competition, the expression Π_U^I above is always smaller than π^S which implies that the new constraint would be satisfied by the previous optimal regulatory contracts. With quantity competition instead $\Pi_U^I \geq \pi^S$. We know that by increasing q the regulator expects that quantities in the unregulated market are increased thus limiting market power inefficiencies. However, with the new constraint she had to limit this expansion of q since otherwise Π_U^I increases and a larger (total) profit Π^I has to be granted. Although the constraint introduces some additional technical difficulties in the derivation of optimal regulation which are beyond the scope of this paper (Π_U^I is a type-dependent and endogenous outside option), our result as for the desirability of integration remain unaffected.

7 Discussion and concluding remarks

We have analyzed optimal regulation of a conglomerate firm that serves both a regulated and an unregulated market. When the conglomerate is allowed integrate its production, economies of scope reduce costs, but the magnitude of these economies is not perfectly known to the regulator and to competitors in the unregulated market, so regulation is distorted by asymmetric information and competition in the unregulated market may also be affected adversely. The regulator must therefore take into account how the unregulated market reacts to decisions in the regulated one, because this in turn affects the conglomerate's incentives in its regulated activity. A notable effect of regulation is an informational externality: regulatory policy action conveys valuable information to the rival firms and its effects (on both markets) depend on the nature of competition in the unregulated market. Accordingly, we discussed optimal regulation and its distortions due to asymmetric information when competition in the unregulated market bears, alternatively, on quantities or on prices. We have shown that with quantity competition this externality simplifies the task of the regulator, whereas price competition complicates it.

We then addressed the issue of desirability of joint production in the conglomerate's activities, where a potential trade-off emerges. On one hand, allowing the conglomerate to integrate productions reduces its costs and, if this is at least partially passed on in the form of lower prices, then consumers may benefit (possibly in both markets). On the other hand, the conglomerate's private information makes the regulator's task more difficult, engendering distortions in regulatory policy and may also make the unregulated market less competitive. Notwithstanding this trade-off, we show that if uncertainty bears solely on the magnitude of scope economies and diseconomies are ruled out, then integrated production is socially desirable; and if allowed to do so, the conglomerate will exploit this opportunity.[31] As usual, this result may inform policy recommendations only with caution since it just provides one pice of a complex picture in which previous analysis have emphasized the cons of diversification by regulated firms (see the discussion in the Introduction).

At least two relevant extensions of the current framework can be conceived. So far, we have considered a situation, where the public authority deciding on integration and the one which sets the regulatory policy share the same objective function. In the EU, while some structural decisions in sectors such as energy or transport are taken at European level, specific regulatory policies are decided by national regulatory authorities. In this case, it may well be that the regulated price dose not fully consider the surplus generated in the competitive sector.

This case has some similarities with our model, but it also entails a few differences. A national sectoral regulator would in any case anticipate that the firm's incentives are affected by its activities in the unregulated market, so that the analysis of incentive compatibility, participation decisions and regulation (which we have carried out in Section 4) would be left qualitatively unaffected. However, a delegation problem would emerge, in that the sectoral regulator would have an objective function, which is not fully in line with the one of the European "principal" who is in charge of structural decisions. We leave this line of research to future work.

A second possible extension could further exploit the informative role played by regulatory policy. In this paper, this informational externality from regulation towards the unregulated market has been framed as a straight dichotomy: either the policy informs the rivals fully or it provides no information at all. Although this simple policy framework is robust (eliminating the possibility that the regulator and the conglomerate collude on the information externality to the unregulated market), it might be suboptimal, if the regulator could "fine tune" information to the unregulated market. As the regulated price is naturally observable, a more sophisticated disclosure policy would then require stochastic regulatory contracts that reveal information only partially.[32] However, it is important to notice that our results on the desirability of an integrated conglomerate would not be affected by this extension. Indeed, a more sophisticated regulatory policy that optimally controls for the information flow would actually make integrated production by the conglomerate even more beneficial. It may be interesting to study the properties of optimal regulation associated

[31] Other potential benefits of integrated production relate to the demand side. For example, customers would clearly find it advantageous having only one provider for both services (joint billing, lower transaction costs summarized in the expression "one stop shop"). Our model can be actually reinterpreted as one where consumers get higher utility from single bill: the cross-market effect may go through the utility function rather than the economies of scope that we have considered.

[32] Interestingly, the optimality of stochastic regulatory contracts may emerge in a context in which, absent the informative role of the regulatory policy, the optimal contract would be deterministic, as in standard models of regulation with asymmetric information.

with an optimal disclosure policy, for example along the lines illustrated in Calzolari and Pavan (2006). In this respect, our results suggest that when competition in the unregulated market bears on quantities, disclosure should be optimal, while with price competition a “no disclosure” policy appears to be preferable. This is an interesting challenge that we plan to explore further in future research.

In the present paper there is a material difference between the conglomerate and its competitors active only in the unregulated market. An interesting extension would be to consider a more symmetric environment in which all firms are regulated in some sector (for example a domestic market) but also meet in a common (international) unregulated market. In this case it could be reasonable to assume some correlation on scope economies so that the informational externality would then be governed by the effects for information sharing among firms in common value environments. We leave this extension for future work.

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8 Appendix

Proof of Proposition 1. *Step 1.* The regulatory program is

$$(\mathcal{P}^I) \begin{cases} \underset{\{(q(\theta),\Pi^I(\theta))\}_{\theta\in\Theta}}{Max} & E_\theta\left\{W^I\left[q,\left(y_1\left(q,\theta,v(q)\right),Y_{-1}\left(q,v(q)\right)\right),\theta\right]\right\} \\ \text{st.} & \\ \Pi^I(\theta)\geq\Pi^I\left(\widehat{\theta};\theta\right) & \forall\left(\widehat{\theta},\theta\right)\in\Theta\times\Theta \quad IC(\theta) \\ \Pi^I(\theta)\geq\pi^S & \forall\theta\in\Theta \qquad IR(\theta) \end{cases}$$

where the objective is defined as in (9) with the difference that outputs in market U also depend on beliefs $v(q)$.[33]

The set of constraints $IC(\theta)$ and $IR(\theta)$ for any $\theta\in\Theta$ can be rewritten as follows,

$$\begin{array}{ll} \overline{\Pi}^I\geq\underline{\Pi}^I+\Delta_\theta\Pi_U\left(\underline{q},v(\underline{q})\right), & IC(\overline{\theta}) \\ \underline{\Pi}^I+\Delta_\theta\Pi_U\left(\overline{q},v(\overline{q})\right)\geq\overline{\Pi}^I, & IC(\underline{\theta}) \\ \overline{\Pi}^I\geq\pi^S, & IR(\overline{\theta}) \\ \underline{\Pi}^I\geq\pi^S. & IR(\underline{\theta}) \end{array}$$

For given quantity q and associated beliefs of the rival firms $v(q)$, a more efficient firm obtains in market U a larger profit so that $\Delta_\theta\Pi_U\left(q,v(q)\right)>0$ for any $q>0$. Hence, constraints $IC(\overline{\theta})$ and $IR(\underline{\theta})$ imply that $IR(\overline{\theta})$ is slack and can be disregarded. This in turn means that constraint $IR(\underline{\theta})$ must be binding at the optimum. In fact, at least one of the two participation constraints has to be binding at the optimum, because, otherwise, the regulator could reduce both profits $\underline{\Pi}^I$, $\overline{\Pi}^I$ by an equal amount, thus keeping incentive compatibility unaffected and increasing the objective function. Furthermore, constraint $IC(\overline{\theta})$ must also be binding at the optimum. In fact, reducing $\overline{\Pi}^I$ the regulator is able to increase the objective function without negatively affecting $IC(\underline{\theta})$. Hence, she optimally reduces $\overline{\Pi}^I$ as much as possible up to the point in which constraint $IC(\overline{\theta})$ binds.

As for constraint $IC(\underline{\theta})$, this can be written as

$$\Delta_\theta\Pi_U\left(\overline{q},v(\overline{q})\right)\geq\Delta_\theta\Pi_U\left(\underline{q},v(\underline{q})\right). \tag{22}$$

Note that if $\overline{q}=\underline{q}$, then $v(\overline{q})=v(\underline{q})$ so that $\Delta_\theta\Pi_U\left(\overline{q},v\right)=\Delta_\theta\Pi_U\left(\underline{q},v\right)$ and constraint $IC(\underline{\theta})$ is trivially satisfied. The case with $\overline{q}\neq\underline{q}$ will be treated in the next steps.

[33] With the usual change of variables, maximization in program $(\mathcal{P}^I)$ is equivalently taken over the contract $\left\{\left(q\left(\theta\right),\Pi^I\left(\theta\right)\right)\right\}_{\theta\in\Theta}$ instead of $\left\{\left(q\left(\theta\right),T\left(\theta\right)\right)\right\}_{\theta\in\Theta}$. In both cases we will indicate the contract with $\mathcal{C}$.

Step 2. Using step 1, we can now further rewrite program $(\mathcal{P}^I)$ in the following equivalent way

$$(\mathcal{P}') \begin{cases} \underset{(\overline{q},\underline{q})}{Max} E_\theta \Big\{ V_R(q) + V_U[Y(q,\theta)] - C[q, y_1(q,\theta);\theta] - \sum_{i\neq 1} C[y_i(q,\theta)] + \\ \qquad -(1-\alpha)\sum_{i\neq 1}\pi_i^I(q,\theta)\Big\} - (1-\alpha)v\Delta_\theta\Pi_U\left(\underline{q}, v(\underline{q})\right) \\ s.t. \quad \Delta_\theta\Pi_U(\overline{q}, v(\overline{q})) \geq \Delta_\theta\Pi_U\left(\underline{q}, v(\underline{q})\right) \qquad IC(\underline{\theta}) \end{cases}$$

Hence, let $\tilde{q}(\theta)$ for $\theta \in \Theta$ be solution of the following two first order conditions

$$\begin{array}{l} \frac{\partial SMC(\overline{q},\overline{\theta})}{\partial q} = 0 \\ \frac{\partial SMC(\underline{q},\underline{\theta})}{\partial q} - (1-\alpha)\frac{v}{1-v}\frac{\partial \Delta_\theta \Pi_U(\underline{q},0)}{\partial q} = 0 \end{array}$$

where $v(q) = 0$ for $q = \tilde{q}(\underline{\theta})$, $v(q) = 1$ for $q = \tilde{q}(\overline{\theta})$ and generically we have $\tilde{q}(\overline{\theta}) \neq \tilde{q}(\underline{\theta})$.

If $\Delta_\theta\Pi_U\left(\tilde{q}(\overline{\theta}), 1\right) \geq \Delta_\theta\Pi_U(\tilde{q}(\underline{\theta}), 0)$, then the optimal regulated quantities $q^*(\theta)$ are $q^*(\theta) = \tilde{q}(\theta)$ for any θ, because these quantities maximize the objective in $(\mathcal{P}')$ and satisfy the unique constraint $IC(\underline{\theta})$.

If instead $\Delta_\theta\Pi_U\left(\tilde{q}(\overline{\theta}), 1\right) < \Delta_\theta\Pi_U(\tilde{q}(\underline{\theta}), 0)$, quantities $\tilde{q}(\overline{\theta}), \tilde{q}(\underline{\theta})$ violate $IC(\underline{\theta})$ so that the optimal solution requires that $IC(\underline{\theta})$ binds. Thus, consider a pair of quantities $\overline{q}, \underline{q}$ such that $\Delta_\theta\Pi_U(\overline{q}, v(\overline{q})) = \Delta_\theta\Pi_U\left(\underline{q}, v(\underline{q})\right)$. This implies $\overline{q} = \underline{q}$. In fact, suppose on the contrary that $\overline{q} \neq \underline{q}$ so that $v(\overline{q}) = 1$, $v(\underline{q}) = 0$ and $\Delta_\theta\Pi_U(\overline{q}, 1) = \Delta_\theta\Pi_U\left(\underline{q}, 0\right)$ or equivalently

$$\Pi_U\left(\overline{q}, \overline{\theta}, 1\right) - \Pi_U\left(\overline{q}, \underline{\theta}, 1\right) = \Pi_U\left(\underline{q}, \overline{\theta}, 0\right) - \Pi_U\left(\underline{q}, \underline{\theta}, 0\right).$$

This last equality is clearly generically impossible unless $\overline{q} = \underline{q}$, thus leading to a contradiction. Hence, when $IC(\underline{\theta})$ binds optimal regulation requires pooling so that quantities do not depend on θ. In this case, whatever its type θ, the conglomerate firm is required to produce a quantity $\tilde{q}$ independent of θ. This quantity can the be obtained by solving the following program,

$$\begin{array}{c} \underset{q}{Max} E_\theta \Big\{ V_R(q) + V_U[Y(q,\theta)] - C[q, y_1(q,\theta);\theta] - \sum_{i\neq 1} C[y_i(q,\theta)] + \\ -(1-\alpha)\sum_{i\neq 1}\pi_i^I(q,\theta)\Big\} - (1-\alpha)v\Delta_\theta\Pi_U(q,v) \end{array}$$

where constraint $IC(\underline{\theta})$ is omitted because, for what stated at the end of step 1, it is satisfied when $\overline{q} = \underline{q} = \tilde{q}$.

Step 3. Given the optimal quantities $q^*(\theta)$ obtained in step 2 we then have that the profit of the conglomerate with low scope economies is $\Pi^I(\underline{\theta}) = \pi^S$ from $IR(\underline{\theta})$ binding and for the efficient one is $\Pi^I\left(\overline{\theta}\right) = \pi^S + \Delta_\theta\Pi_U\left(\underline{q}^*, v\left(\underline{q}^*\right)\right)$ from $IC(\overline{\theta})$ binding. ■

Proof of Proposition 2. *Step 1.* We first derive the ranking on quantities $\tilde{q}(\underline{\theta}), \tilde{q}(\overline{\theta})$ defined in the text of Proposition 1.

We show that the distortion $\partial\Delta_\theta\Pi_U\left(q,v\right)/\partial q$ in the pricing conditions (14) and (15) is positive independently of the type of strategic interaction in the unregulated market. To see this, for the generic strategic variable x_1 of the conglomerate in market U consider the associated the first order condition,

$$\frac{\partial}{\partial x_1}\Pi^I(\widehat{q}, x_1, X_{-1}; \theta) = 0.$$

This condition depends on θ through the marginal cost $\frac{\partial C(q,y_1;\theta)}{\partial y_1}$. Now, the properties of the cost function (1)-(3) state that (i) this marginal cost is reduced by a larger q, due to scope economies, and (ii) this reduction is stronger the higher is θ (i.e. with large scope economies). Hence, for the implicit function theorem, it follows that the equilibrium profit $\Pi_U\left(q,\theta,v\right)$ is increasing in q, in θ and that the profit increase caused by a larger q is larger the higher is θ. Hence, keeping constant the rivals' beliefs for (i.e. for a given v) we have

$$\frac{\partial\Pi_U\left(q,\overline{\theta},v\right)}{\partial q} \geq \frac{\partial\Pi_U\left(q,\underline{\theta},v\right)}{\partial q} \geq 0, \tag{23}$$

and then

$$\frac{\partial\Delta_\theta\Pi_U\left(q,v\right)}{\partial q} \geq 0. \tag{24}$$

With the sign of (24) we then obtain the ranking on optimal regulated output. In particular, if with full information scope economies induce a larger regulated output $\underline{q}^I_{FI} \leq \overline{q}^I_{FI}$, then (24) implies $\tilde{q}(\underline{\theta}) \leq \tilde{q}(\overline{\theta})$ with strict inequality if $\overline{\theta} > \underline{\theta}$.

Step 2. Notwithstanding the monotonicity proved in the previous step, Proposition 1 illustrates that, quantities $\tilde{q}(\underline{\theta}), \tilde{q}(\overline{\theta})$ may fail to be incentive compatible. Here we analyze when this is the case and we check whether these outputs satisfy constraint $IC(\underline{\theta})$. As illustrated in (22), the incentive compatibility constraint for type $\underline{\theta}$ is equivalent to

$$\left[\Pi_U\left(\overline{q},\underline{\theta},1\right) - \Pi_U\left(\underline{q},\underline{\theta},0\right)\right] - \left[\Pi_U\left(\overline{q},\overline{\theta},1\right) - \Pi_U\left(\underline{q},\overline{\theta},0\right)\right] \leq 0. \tag{25}$$

We now decompose this inequality into the three effects of cost announcement. To consider the simple *cost-efficiency effect* of announcement, let us fictitiously assume that outputs y_1 and y do not depend on θ and q, in which case (25) would be

$$\begin{aligned}&\left[-C\left(\overline{q},y_1;\underline{\theta}\right)+C\left(\overline{q},0;\underline{\theta}\right)+C\left(\underline{q},y_1;\underline{\theta}\right)-C\left(\underline{q},0;\underline{\theta}\right)\right]+\\&-\left[-C\left(\overline{q},y_1;\overline{\theta}\right)+C\left(\overline{q},0;\overline{\theta}\right)+C\left(\underline{q},y_1;\overline{\theta}\right)-C\left(\underline{q},0;\overline{\theta}\right)\right]\leq 0\end{aligned}$$

or equivalently

$$\int_{\underline{q}}^{\overline{q}}\int_0^{y_1}\frac{\partial^2 C\left(h,u;\overline{\theta}\right)}{\partial y_1\partial q}dudh-\int_{\underline{q}}^{\overline{q}}\int_0^{y_1}\frac{\partial^2 C\left(h,u;\underline{\theta}\right)}{\partial y_1\partial q}dudh\leq 0.$$

It is then immediate that properties of the cost function (1)-(3) imply that the previous inequality is satisfied by standard monotonicity, i.e. for $\underline{q}\leq\overline{q}$.. Hence, the cost-efficiency effect alone would imply that outputs $\left(\tilde{q}(\underline{\theta}),\tilde{q}(\overline{\theta})\right)$ are implementable.

We now add the *direct strategic effect* reintroducing the dependence of y_1 and y on θ and q, but *keeping the rivals' beliefs unchanged*. To this end let assume that rivals are fully informed so that even if regulated output is $q(\hat{\theta})$ and real scope economies are associated to type θ, rivals' beliefs are still such that $\Pr(\theta|q(\hat{\theta}))=1$. Constraint (25) would then be

$$\begin{aligned}&\left[\Pi_U\left(\overline{q},\underline{\theta},0\right)-\Pi_U\left(\underline{q},\underline{\theta},0\right)\right]-\left[\Pi_U\left(\overline{q},\overline{\theta},1\right)-\Pi_U\left(\underline{q},\overline{\theta},1\right)\right]=\\&\textstyle\int_{\underline{q}}^{\overline{q}}\frac{\partial\Pi_U(h,\underline{\theta},0)}{\partial q}dh-\int_{\underline{q}}^{\overline{q}}\frac{\partial\Pi_U\left(h,\overline{\theta},1\right)}{\partial q}dh\leq 0\end{aligned}\tag{26}$$

where the notable difference with (25) is that rivals' beliefs on θ are always correct: independently of q then $v(q)=1$ if type is $\overline{\theta}$ and $v(q)=0$ if $\underline{\theta}$. Now, from (1)-(3) we know that the marginal cost of y_1 is decreasing in q for any θ, i.e. $\frac{\partial^2 C(q,y_1;\theta)}{\partial q\partial y_1}\leq 0$ and this marginal cost reduction associated with a larger q is larger the higher is θ.. Hence, independently of the type of competition we have,

$$0\leq\frac{\partial\Pi_U\left(q,\underline{\theta},0\right)}{\partial q}\leq\frac{\partial\Pi_U\left(q,\overline{\theta},1\right)}{\partial q}.$$

These inequalities imply that for both the cost-efficiency and the direct strategic effects, constraint (26) is verified by the simple monotonicity condition for outputs $\underline{q}\leq\overline{q}$.

We are now left to study the *belief-related strategic* effect. Adding and subtracting $\Pi_U\left(\overline{q},\underline{\theta},0\right)$ and $\Pi_U\left(\overline{q},\overline{\theta},0\right)$ from (25), constraint $IC(\underline{\theta})$ becomes

$$\begin{aligned}&\left[\Pi_U\left(\overline{q},\underline{\theta},1\right)-\Pi_U\left(\overline{q},\underline{\theta},0\right)-\left[\Pi_U\left(\underline{q},\underline{\theta},0\right)-\Pi_U\left(\overline{q},\underline{\theta},0\right)\right]\right]-\\&\left[\Pi_U\left(\overline{q},\overline{\theta},1\right)-\Pi_U\left(\overline{q},\overline{\theta},0\right)-\left[\Pi_U\left(\underline{q},\overline{\theta},0\right)-\Pi_U\left(\overline{q},\overline{\theta},0\right)\right]\right]\leq 0,\end{aligned}$$

or, equivalently

$$\begin{aligned}&\Pi_U\left(\overline{q},\underline{\theta},1\right)-\Pi_U\left(\overline{q},\underline{\theta},0\right)-\left[\Pi_U\left(\overline{q},\overline{\theta},1\right)-\Pi_U\left(\overline{q},\overline{\theta},0\right)\right]+\\ &-\left[\int_{\underline{q}}^{\overline{q}}\left(\frac{\partial\Pi_U\left(h,\overline{\theta},0\right)}{\partial q}-\frac{\partial\Pi_U\left(h,\underline{\theta},0\right)}{\partial q}\right)dh\right]\leq 0.\end{aligned} \tag{27}$$

The second line is negative whenever $\underline{q}\leq\overline{q}$ for the same reasons illustrated above on the direct strategic effect. On the contrary, the sign of the first line depends on the type of competition in market U. The function $\Pi_U\left(q,\theta,1\right)-\Pi_U\left(q,\theta,0\right)$ uniquely refers to the effect of a change of rivals' beliefs for any q and θ, that is for given marginal costs of y_1. With quantity competition, or more generally with strategic substitutability, we clearly have $\Pi_U\left(q,\theta,1\right)\geq\Pi_U\left(q,\theta,0\right)$, whilst $\Pi_U\left(q,\theta,1\right)\leq\Pi_U\left(q,\theta,0\right)$ with price competition or strategic complementarity. Furthermore, the absolute value $\left|\Pi_U\left(q,\theta,1\right)-\Pi_U\left(q,\theta,0\right)\right|$ is increasing in θ because a smaller marginal cost of y_1 (induced by a larger θ) amplifies the change induced by different beliefs, so that we have

$$\begin{aligned}&\Pi_U\left(\overline{q},\underline{\theta},1\right)-\Pi_U\left(\overline{q},\underline{\theta},0\right)-\left[\Pi_U\left(\overline{q},\overline{\theta},1\right)-\Pi_U\left(\overline{q},\overline{\theta},0\right)\right]\leq 0 \quad \text{with substitutability,}\\ &\Pi_U\left(\overline{q},\underline{\theta},1\right)-\Pi_U\left(\overline{q},\underline{\theta},0\right)-\left[\Pi_U\left(\overline{q},\overline{\theta},1\right)-\Pi_U\left(\overline{q},\overline{\theta},0\right)\right]\geq 0 \quad \text{with complementarity.}\end{aligned} \tag{28}$$

From the signs in (28) and $IC(\underline{\theta})$ written as (27) we then obtain the following.

First, with strategic complementarity in market U the sign in (28) implies that monotonicity $\underline{q}\leq\overline{q}$ be not sufficient to satisfy $IC(\underline{\theta})$. When the (absolute value of the) first line in (27) is larger than the second line in the case $\underline{q}=\tilde{q}(\underline{\theta}),\overline{q}=\tilde{q}(\overline{\theta})$, then quantities $\tilde{q}(\theta)$ are not incentive compatible in which case optimal regulation is uniform and defined by (15). Quantity $\tilde{q}$ is obtained from a pricing condition averaging with respect to type $\overline{\theta}$ and $\underline{\theta}$ so that $\tilde{q}\leq\overline{q}_{FI}^{I}$ but $\tilde{q}\gtreqless\underline{q}_{FI}^{I}$ because two countervailing effects are at play. On the one hand, the distortionary term $\frac{\partial\Delta_\theta\Pi_U(\tilde{q},v)}{\partial q}$ in (15) reduces $\tilde{q}$.. On the other hand, the averaging with respect to $\overline{\theta}$ and $\underline{\theta}$ increases $\tilde{q}$ as compared to $\underline{q}_{FI}^{I}$.. Furthermore, for the same reasons, we also have that $\tilde{q}(\underline{\theta})\leq\tilde{q}\leq\tilde{q}(\overline{\theta})$ so that $\Delta_\theta\Pi_U\left(\tilde{q},v\right)\geq\Delta_\theta\Pi_U\left(\tilde{q}(\underline{\theta}),0\right)$ which implies that the conglomerate gains and that the regulator's task is complicated when the rivals are uninformed on the level of scope economies. Finally, if the first line in (27) is larger than the second line with $\underline{q}=\tilde{q}(\underline{\theta}),\overline{q}=\tilde{q}(\overline{\theta})$, then optimal regulation is discriminatory, $\underline{q}^*=\tilde{q}(\underline{\theta})\leq\underline{q}_{FI}^{I}$, $\overline{q}^*=\tilde{q}(\overline{\theta})=\overline{q}_{FI}^{I}$. That the conglomerate gains from the rivals being uniformed can be seen in this case with discriminatory regulation by considering the firm's rent $\Pi^I\left(\overline{\theta}\right)=\pi^S+\Delta_\theta\Pi_U(\underline{q}^*,0)$ where $\Delta_\theta\Pi_U(\underline{q}^*,0)=\Pi_U(\underline{q},\overline{\theta},0)-\Pi_U(\underline{q},\underline{\theta},0)$. For strategic complementarity we have that $\Pi_U(\underline{q},\overline{\theta},0)\geq\Pi_U(\underline{q},\overline{\theta},1)$ and also in this case the conglomerate benefits when the rivals are uninformed.

With strategic substitutability, the monotonicity $\underline{q} \leq \overline{q}$ implies that the incentive compatibility constraint (25) is satisfied from which it follows that optimal regulated quantities are $\tilde{q}(\underline{\theta}), \tilde{q}(\overline{\theta})$ defined by (14). This in turn gives the the comparison with quantities in the case of full information. Since the first line in (27) is negative the regulator's task is easened by the rivals being uninformed. Furthermore, since for strategic complementarity $\Pi_U(\underline{q}, \overline{\theta}, 0) \leq \Pi_U(\underline{q}, \overline{\theta}, 1)$, the conglomerate gains a smaller rent $\Pi^I\left(\overline{\theta}\right)$ being the rivals uninformed. Finally, monotonicity $\underline{q} \leq \overline{q}$ is here sufficient but not necessary for incentive compatibility. ■

Proof of Proposition 3. The proof is organized separating the study of quantity and price competition in market U, respectively strategic substitutability and complementarity.

Strategic complementarity (price-competition) in market U. Let $\mathcal{I}^*$ be the information set in which neither the regulator nor the rivals know θ, as in the model setup, and $\mathcal{C}^*$ be the associated optimal regulatory contract illustrated in Proposition 1.

With information set $\mathcal{I}^*$, contract $\mathcal{C}^S$ satisfies all constraints $IC(\theta)$ and $IR(\theta)$ for any $\theta \in \Theta$ because $\mathcal{C}^S$ does not depend on θ and it is thus implementable. This allows to evaluate welfare with integration and information set $\mathcal{I}^*$ when the regulator offers the contract $\mathcal{C}^S$, i.e. $EW^I(\mathcal{C}^S, \mathcal{I}^*)$. We can now compare this welfare with the that associated with separation W^S. We now have

$$\begin{aligned} EW^I(\mathcal{C}^S, \mathcal{I}^*) - W^S = \; & E_\theta\left[V_U\left(Y(q^S, \theta, v)\right) - Y(q^S, \theta, v)p^U\left(Y(q^S, \theta, v)\right)\right] - \left[V_U\left(Y^S\right) - Y^S p^U\left(Y^S\right)\right] + \\ & + \alpha\left[\sum_{i \neq 1}^{n} \pi^I\left(q^S, \theta\right) + \Pi_U\left(q^S, \theta\right) - \sum_{i=1}^{n} \pi_i^S\right] \end{aligned}$$

The difference between this expression for $EW^I(\mathcal{C}^S, \mathcal{I}^*) - W^S$ with the equivalent expression for $EW^I(\mathcal{C}^S, \mathcal{I}') - W^S$ is that in the former rivals' beliefs correspond to their priors $\Pr(\theta = \overline{\theta}) = v$ and $\Pr(\theta = \underline{\theta}) = 1 - v$ and do not depend on $q(\theta)$. In fact, in the information set $\mathcal{I}^*$ they are not informed, contrary to $\mathcal{I}'$, and regulatory process associated with $\mathcal{C}^S$ is totally uninformative.

However, with price competition facing an integrated conglomerate induces the rivals' to reduce their prices and this increases both consumers' surplus and total profits in the market U. Hence, both the first and the second line in $EW^I(\mathcal{C}^S, \mathcal{I}^*) - W^S$ are positive so that we have

$$EW^I(\mathcal{C}^S, \mathcal{I}^*) \geq W^S.$$

Now note again that regulation $\mathcal{C}^S$ is sub optimal with information set $\mathcal{I}^*$ so that with the associated optimal regulation we have $EW^I(\mathcal{C}^*,\mathcal{I}^*) \geq EW^I(\mathcal{C}^S,\mathcal{I}^*)$ which finally implies the result,

$$EW^I(\mathcal{C}^*,\mathcal{I}^*) \geq EW^I(\mathcal{C}^S,\mathcal{I}^*) \geq W^S.$$

Strategic substitutability (quantity-competition) in market U. We first prove that optimal regulation $\mathcal{C}'$ for information set $\mathcal{I}'$ is discriminatory and in particular we generically have $\overline{q}' > \underline{q}'$. Optimal regulation with information set $\mathcal{I}'$ can be obtained following the proofs of Propositions 1 and 2, keeping in mind that the unique difference consists in the rivals being fully informed. Exactly as in the proof of Proposition 2, with (24) we show that, generically, $\frac{\partial \Delta_\theta \Pi_U(q,v)}{\partial q} > 0$, which immediately implies that the optimal regulation $\mathcal{C}'$ with information set $\mathcal{I}'$ is generically monotone $\overline{q}' > \underline{q}'$.

Now we show that contract $\mathcal{C}'$ is incentive compatible and individual rational also with information $\mathcal{I}^*$, i.e. it satisfies all constraints $IC(\theta)$ and $IR(\theta)$ for any $\theta \in \Theta$. This is again proved in step 2 of the proof of Proposition 2. In fact, the only difference between information sets $\mathcal{I}^*$ and $\mathcal{I}'$ is that in the former rivals are not informed, while they are informed in the latter. We know from the proof of Proposition 2 that with strategic substitutability the belief strategic effect due to the rivals' lack of information relaxes the compatibility constraint $IC(\underline{\theta})$ so that any pair of monotone outputs $\overline{q} \geq \underline{q}$ is incentive compatible (see (28) and related analysis).

This allows one to evaluate the welfare $EW^I(\mathcal{C}',\mathcal{I}^*)$ that would prevail with information set $\mathcal{I}^*$ if the regulator allowed the conglomerate to integrate its activities and offered the contract $\mathcal{C}'$. For what stated above, contract $\mathcal{C}'$ is discriminatory so that it discloses perfect information on scope economies. Hence, the rivals' choices are the same in the two different information sets $\mathcal{I}^*$ and $\mathcal{I}'$ so that $EW^I(\mathcal{C}',\mathcal{I}^*)$ differs from $EW^I(\mathcal{C}',\mathcal{I}')$ uniquely as for the conglomerate's rent:

$$\begin{aligned} EW^I(\mathcal{C}',\mathcal{I}^*) - EW^I(\mathcal{C}',\mathcal{I}') = -(1-\alpha)v\left\{\Pi_U\left(\underline{q}',\overline{\theta},0\right) - \Pi_U\left(\underline{q}',\underline{\theta},0\right) - \left[\Pi_U\left(\underline{q}',\overline{\theta},1\right) - \Pi_U\left(\underline{q}',\underline{\theta},0\right)\right]\right\} = \\ = -(1-\alpha)v\left[\Pi_U\left(\underline{q}',\overline{\theta},0\right) - \Pi_U\left(\underline{q}',\overline{\theta},1\right)\right], \end{aligned}$$

where for strategic substitutability we have $\Pi_U\left(\underline{q}',\overline{\theta},1\right) \geq \Pi_U\left(\underline{q}',\overline{\theta},0\right)$. It then follows

$$EW^I(\mathcal{C}',\mathcal{I}^*) \geq EW^I(\mathcal{C}',\mathcal{I}').$$

As a final step we now prove that

$$EW^I(\mathcal{C}',\mathcal{I}') \geq W^S$$

so that the two previous inequality with the obvious

$$EW^I(\mathcal{C}^*,\mathcal{I}^*) \geq EW^I(\mathcal{C}',\mathcal{I}^*).$$

allow to finally have

$$EW^I(\mathcal{C}^*,\mathcal{I}^*) \geq EW^I(\mathcal{C}',\mathcal{I}^*) \geq EW^I(\mathcal{C}',\mathcal{I}') \geq W^S.$$

Being independent of θ, the regulatory contract $\mathcal{C}^S$ is individually rational and incentive compatible when applied to integration with information set $\mathcal{I}'$, i.e. $\mathcal{C}^S$ satisfies constraints $IC(\theta)$ and $IR(\theta)$ for any $\theta \in \Theta$. This allows to evaluate the expected welfare with integration when the regulator offers the regulatory contract $\mathcal{C}^S$ and rivals are fully informed, i.e. $EW^I(\mathcal{C}^S,\mathcal{I}')$, and proceed with the following comparison:

$$\begin{aligned} &EW^I(\mathcal{C}^S,\mathcal{I}') - W^S = \\ &\quad E_\theta\left[V_U\left(Y(q^S,\theta,v(\theta))\right) - Y(q^S,\theta,v(\theta))p^U\left(Y(q^S,\theta,v(\theta))\right)\right] - \left[V_U\left(Y^S\right) - Y^S p^U\left(Y^S\right)\right] + \\ &\quad + \alpha\left[\sum_{i\neq 1}^n \pi^I\left(q^S,\theta\right) + \Pi_U\left(q^S,\theta\right) - \sum_{i=1}^n \pi_i^S\right] \end{aligned}$$

where we have indicated with $v(\theta) = 1$ if $\theta = \overline{\theta}$ and $v(\theta) = 0$ if $\theta = \underline{\theta}$ the rivals' degenerate beliefs. Both lines on the R.H.S. are positive because the only difference between $EW^I(\mathcal{C}^S,\mathcal{I}')$ and W^S is that in the former the conglomerate benefits of scope economies and is thus more efficient in market U. Thus we have $EW^I(\mathcal{C}^S,\mathcal{I}') \geq W^S$. Now, notice that regulation $\mathcal{C}^S$ is suboptimal with information $\mathcal{I}'$ so that clearly $EW^I(\mathcal{C}',\mathcal{I}') \geq EW^I(\mathcal{C}^S,\mathcal{I}')$ which proves the result that $EW^I(\mathcal{C}',\mathcal{I}') \geq W^S$. ■