Regulating a multi-utility firm*

Giacomo Calzolari† Carlo Scarpa‡

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Abstract

We study optimal regulation of a multi-utility firm active both in a regulated market and in a competitive unregulated sector. Multi-utility's ability to bundle activities in the two markets generates scope economies whose dimension is firm's private information because bundling makes costs observability more problematic. Regulation is thus affected by asymmetric information and must account for firm's (and rivals') reaction in the unregulated sector. In this context we also study whether the regulator should allow the firm to integrate and bundle activities or not. A potential trade-off thus emerges. On one side, bundling generates greater technological efficiency, on the other side asymmetric information induced by bundling makes regulation less efficient. We show that bundling activities into an integrated multi-utility is socially desirable both when firms compete on prices or on quantities in the unregulated market, unless diseconomies of scope may emerge from bundling.

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

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

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†Department of Economics, University of Bologna, Italy. E-mail: calzolari@economia.unibo.it

‡Dipartimento di Scienze Economiche, Università di Brescia cscarpa@eco.unibs.it

1 Introduction

Many firms active in highly regulated sectors often operate in unregulated markets as well. This is particularly frequent for firms in utility services such as water, gas, electricity, waste, transports, and telecommunication. The recent surge of such “multi-utility” firms both in developed and developing countries is a consequence of several factors, from the merger wave of the last decades, to the worldwide process of liberalization and also some recent technological advances (e.g. the possibility to use electricity distribution systems for telecommunications).

Centrica in the UK operates both gas and electricity transmission as well as some services in competitive segments of energy sectors and also telecommunication and financial services. Vivendi and Suez-Lyonnaise des Eaux are well rooted in water, energy, gas, waste management and telecommunication in France and in many other countries. RWE in Germany and Enel in Italy, both operate in regulated as well as unregulated energy markets and telecommunication. Poste Italiane is a regulated monopolist in the postal sector and recently entered the banking sector with very aggressive strategies. In US one third of over two hundred electricity retailers also offer telecommunication services. In addition to these "giants" often operating all over the world, there is also a multitude of municipal enterprises which are locally embedded but offer a wide array of services in regulated and unregulated sectors.[1]

The reasons for the existence of multi-utilities are several. The main one goes under the heading “synergy”, a catch-all term indicating direct economies of scope in the supply of horizontally diversified services, but also the ability of a firm to capture customers in another market, using its protected position in the regulated market. Thus, there are both technological and commercial reasons. While the presence of economies of scope and consumers’ convenience (e.g. from the "single-bill" for a bundle of utility services) seems to be a strong argument in favour of horizontal diversification, nevertheless multi-utilities also provide regulatory challenges. Joint activities by a multi-utility firm can make more difficult for regulators to efficiently perform their tasks and may also rise concerns for competition policy. A regulated firm operating in competitive sectors might apportion costs within its activities so that captive customers of monopolized sectors are effectively paying for the firm’s activities in other competitive markets. Moreover, allowing a regulated firm to use part of its assets to compete in unregulated segments might give this firm an advantage over its rivals, or it might leverage on its monopolist position to get easier access to customers in competitive markets and all this is seen as detrimental to fair competition. A multi-utility may also take advantage of sectoral regulators who fail to coordinate their policies.

However, the first concern faced by regulators of multi-utility firms is probably an informational one. For example, in a joint document issued by the sectoral utility regulators in UK (OFWAT, 1998), the lack of information about costs in the several multi-utility’s activities emerged as the first issue to be properly addressed for effective regulation of this type of firms. In particular, regulators

[1] See Sommer (2001) for more details. Calzolari (2001) and (2004) analyze regulation of multinational firms operating in utility sectors.

will need to gain knowledge about costs and benefits from the creation of the multi-utility, but they fear that the observability of the cost of regulated activities, which is already problematic in standard situations, would dramatically deteriorate if the regulated firm operates in many other markets.[2]

We thus have a conflict between the potential benefits of multi-utility firms and potential cost. In this paper we assess these concerns and focus our analysis on the trade-off between technical efficiency from scope economies—which points in favour of diversification by multi-utilities—and the efficiency of the regulatory process, whereby integration into a multi-utility brings about greater opacity into the firm's accounts. While nobody seriously contends that with multi-utilities there are (at least potential) cost savings, and that this could be advantageous for the final customers as well when cost savings are at least partially passed on prices, we stress that the actual entity of such cost savings is generally unknown, so that the decision to diversify makes informational asymmetries between the regulator and the multi-utility even more serious. Indeed, integration increases the complexity of the firm's organization and, as usual, the firm is certainly in a much better position to assess the exact level of scope economies. Hence, horizontal integration brings about an additional element of uncertainty for the regulator that increase the complexity of her tasks.[3]

With a first step of our analysis, we identify optimal regulation when a monopolist is allowed to operate in unregulated markets as well and privately knows the dimension of scope economies arising from joint production. To this end we emphasize that the regulator may not be the unique player affected by asymmetric information on scope economies because the rival firms in the competitive sector may be in a similar condition. In fact, when multi-utility diversification is allowed, these firms face a new competitor potentially more efficient and whose costs (better, economies of scope) are not perfectly known. In this respect, the activities of the multi-utility in the regulated sector, such as the regulated price, the quantity offered and possibly the regulatory transfers, are clearly important sources of information on the level of scope economies for the competitors in the regulated market. This highlights both that the regulation in place will transmit relevant information to the unregulated markets and also that the multi-utility firm's incentives to disclose information to the regulator are affected by its activities in the unregulated market.

Notably, we show that the effects of this informational externality will very much depend on the type of competition occurring in the unregulated market. In particular, when firms compete on quantities, the multi-utility is negatively affected by the informational externality to the unregulated

[2]In the survey by Marketline ("*EU Multi-utilities: Strategic Positioning in Competitive Markets,*" Marketline International, 1998, London) conducted among managers of (European) multi-utility firms, respondents showed a large variability in their reports. In Germany managers accounted for 25% of total cost reduction thanks to horizontal integration, in Austria only 18%, in UK 17% and much less in other countries.

[3]The role of information in regulation has been repeatedly stressed by the "New Regulatory Economics" (see Laffont and Tirole 1993). With respect to multi-utilities there is a considerable shortage of econometric studies providing systematic assessment of the dimension of possible economies of scope. A first attempt is Fraquelli, Piacenza and Vannoni (2004).

market and the regulator can more easily induce truthful revelation of scope economies thus reducing the distortions in the regulated sector. Announcing a low level of scope economies to obtain lenient regulation, the multi-utility obtains the countervailing effect of induing the rival firms to expand output in the unregulated market. On the contrary, with price competition, the externality favors the multi-utility so that its profit increase, and the regulator may be constrained to use a uniform regulatory policy which is independent of the effective level of scope economies (pooling regulation).

Then we go on exploring whether an (optimally) regulated firm should be allowed to diversify horizontally, thus forming a multi-utility and to compete in other markets.[4] On one side, the multi-utility brings about economies of scope that will be lost if separation or unbundling of activities is imposed. On the other side, as discussed above, the regulator's task complicates because the exact dimension of scope economies is generally private information of the firm, thus reducing efficiency of regulation. We perform this analysis taking into account welfare in both the regulated and unregulated market.

If the regulator knew the level of scope economies, integration would certainly be desirable also because the rival firms could simply convey the value of scope economies by inspecting the regulated quantity and price that have been implemented by the informed regulator. The analysis is more subtle when the level of scope economies is private information of the multi-utility. In fact, when integration generates (or strengthens) asymmetric information one needs to consider some additional effects. First, the regulator must allow the firm to retain some extra-rents in order to induce information revelation. Second, as discussed above, extracting information may be so difficult that the optimal regulatory policy entails uniform prices for different cost levels (pooling), with a reduction in allocative efficiency as well. Finally, the game in the unregulated market will be one of asymmetric information, unless the regulatory policy provides information to the rival firms.[5] In this case, the welfare effects of a multi-utility are not easily predictable. This is even more true if the number of active rivals in the unregulated market may be affected by the decisions of the multi-utility so that, allowing this kind of diversification may affect the structure of the industry.

With this respect we show that, despite horizontal integration and bundling multi-utility's activities brings about informational problems for the regulator and for the competitors in the unregulated market, nonetheless these negative effects are of lesser importance relative to the efficiency gains of integration. Surprisingly, this holds true both when in the unregulated market firms compete on quantities or on prices. With quantity competition the informational externality

[4]The issue of whether a regulated firm should be allowed to operate in other markets where competition prevails is at the very core of the utility policy in the European Union. For instance, the EC Directives on energy markets stress that integrated firms should at least create separate accounts for branches operating in different sectors, and many countries require stronger forms of vertical and horizontal "unbundling". The problem with these policies is that, almost by definition, economies of scope cannot be properly attributed to single activities and separated in different books.

[5]It is well-known from the literature on information sharing in oligopolies (see Vives 1999, Chapter 8, for a survey) that total welfare may reduce when firms compete under asymmetric information.

to the unregulated market actually damages the multi-utility, thus favoring integration into a multi-utility. Furthermore, we show that, even if with price competition the multi-utility is favored by the informational externality, bundling activities into an integrated multi-utility is socially desirable also when firms compete on prices. Our analysis thus shows that multi-utilities seem to pass the test on integration as long as uncertainty uniquely concerns the dimension of scope economies that realize. Things are different it bundling of activities may sometimes bring about diseconomies of scope, as it may happen if integration of activities is not driven by efficiency reasons rather than managers' desire to run large firms (as in the "free-cash-flow" hypothesis of mergers). If this is a case, then the desirability of integration of multi-utility's activities is clearly weakened and the regulator should trade-off the positive effects of integration illustrated in our analysis with the risk of ending up with a less efficient multi-utility.

Some early papers have addressed the problems and the desirability of horizontal diversification with regulated firms mainly in terms cross-subsidies towards unregulated sectors (Brauetigam and Panzar 1989, Brennan 1990, Brennan and Palmer 1994). More recently, Sappington (2003) analyzes effort diversion from regulated to unregulated activities together with firm's ability to procure unnecessary expenditures (i.e. cost padding) and discusses the desirability of diversification. These papers widely document the potential risks and benefits of diversification. However, these analysis differs from our in that they emphasize the role of cross-subsidies and effort allocation, whilst we consider the informational issues related to the dimension of scope economies and the informational externality generated by the regulatory policy towards the unregulated market.

Lewis and Sappington (1989a) study a model where costs of regulated activities are negatively correlated to profitability in the unregulated sector. Within this specific setting and with a black-boxed description of profitability in the competitive market, they show how "countervailing incentives" may affect regulation.[6,7]

Finally, informational externalities arise in many different contexts. Iossa (1999) considers the design of a regulated two-product industry with interdependent and unknown demand. She shows that the desirability of an integrated monopolist rather than two separate firms depends on the interplay between the demand complementarity/substitutability of the two products and the informational externality generated by the two independent firms. Katzman and Rhodes-Kropf (2002) and by Zhong (2002) examine the revenue effect of different bid announcement policies in standard auctions followed by Bertrand and Cournot competition. Calzolari and Pavan (2004) study the optimal exchange of information between two principals who contract sequentially with the same privately-informed agent. They show that the upstream principal may gain by disclosing information downstream exactly when there are countervailing incentives or if activities are substitute.

[6] A somehow related problem is the one labelled "ratchet effect", whereby revealing information may have negative consequences on future contracts (Freixas, Guesnerie and Tirole, 1985).

[7] Chaaban (2004) studies the effects of various cost-apportionment rules for a joint fixed-cost which is privately known by the multi-utility.

The paper is organized as follows. The next section introduces the general model and the main assumptions. Section 3 provides an analysis of benchmark cases, with full information and separation of activities. Section 4 derives optimal regulation in the cases of bundling multi-utility's activities. Section 5 uses these results to study the welfare effects of integration. Section 6 exploits a specific model to deepen the analysis both in the case of quantity and price competition. Section 7 concludes the paper. Proofs are in the Appendix.

2 Model Set-up

We consider two markets. Market R is a regulated natural monopoly while the other sector U is an unregulated oligopoly with n operating firms, indexed by $i = 1, ..., n$, that compete on quantities. Inverse demand in sector R is $p_R(q)$ where q is output and $p_U(Y)$ in the unregulated sector U where $Y = \sum_{i=1}^{n} y_i$ is the total consumption in that sector and y_i is firm i's production. Demand functions are decreasing, (twice) differentiable and independent.

A (unique) multi-utility firm operates in both the regulated and unregulated markets, respectively producing outputs q and y_1 (so index $i = 1$ is reserved to the multi-utility). If no legal unbundling is imposed, this firm enjoys economies of scope which are lost otherwise. Indeed, unbundling makes impossible for the multi-utility to share assets and internal resources that may bring about cost savings in production. More precisely let $C(q, y_1; \theta)$ denote the total production cost of the multi-utility absent any bundling restriction, where θ is an efficiency parameter. If unbundling is imposed, the multi-utility's total costs is $C(0, y_1; \theta) + C(q, 0; \theta)$. No restrictions in bundling activities provides a benefit $B(q, y_1; \theta)$ in terms of lower costs,

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

Parameter θ describes the entity of such cost savings so that

$$B(q, y_1; \theta'') \geq B(q, y_1; \theta'), \text{ for any } (q, y_1) \text{ and } \theta'' \geq \theta' \tag{2}$$

i.e. the larger is θ, the higher the cost saving obtained with integration. Furthermore, if unbundling is imposed, then θ has no bite on costs so that for any $\theta'' \neq \theta'$,

$$C\left(q, y_1; \theta''\right) = C\left(q, y_1; \theta'\right), \text{ with } q = 0 \text{ or } y_1 = 0. \tag{3}$$

Conditions (1) to (3) may also accommodate economies of scope due to joint / common fixed costs. However, in the current framework we will only deal with economies of scope associated with *variable (non-separable) costs*, so that a higher value of θ reduces the marginal cost for both outputs but it has no fixed-costs effects, namely we assume[8,9]

$$\begin{array}{l}\text{(i) } B(q,y_1;\theta)=0, \text{ with } q=0 \text{ or } y_1=0\\ \text{(ii) } \frac{\partial C(q,y_1;\theta'')}{\partial x}\leq\frac{\partial C(q,y_1;\theta')}{\partial x} \text{ for any } (q\neq 0, y_1\neq 0) \text{ and } \theta''\geq\theta', \text{ with } x\in\{q,y_1\}\end{array} \tag{4}$$

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

$$C(y_i)\equiv C(0,y_1;\theta), \forall\ y_1=y_i.$$

so that profits of any unregulated firm i is

$$\pi_i(y_i,Y_{\_i})=y_ip_U(Y)-C(y_i)$$

where $Y_{\_i}=\sum_{j\neq i}y_j$ is the sum of outputs of all firms except firm i.[10]

With no bundling restrictions, the multi-utility is allowed to integrate all its activities and the *total* profit is (the apex I stands for integration)

$$\Pi^I\left(q,y_1,Y_{\_1};\theta\right)=qp(q)+y_1p_U(Y)-C(q,y_1;\theta)-T, \tag{5}$$

where T is a tax/transfer the regulator may use for regulation (see later). On the contrary, when separation is imposed and the multiutility is obliged to unbundle its activities, the profit is (the apex S stands for separation)

$$\Pi^S+\pi_1(y_1,Y_{\_1})$$

where

$$\Pi^S=qp(q)-C(q,0;\theta)-T. \tag{6}$$

The regulator maximizes an utilitarian objective function which is a weighted sum of net consumer surplus in the two markets, firms profits and taxes (or transfers). Let $V_j(x)=\int_0^x p_j(u)du$ denote gross consumer surplus in sector $j=R,U$ for a level of consumption x. The regulator's

[8] Function C is also assumed twice differentiable w.r.t. q and y_1. If it is also differentiable w.r.t. θ, then condition (2) implies $\partial^3C/\partial q\partial y_1\partial\theta\leq 0$, whilst (2) and (3) imply $\partial C/\partial\theta\leq 0$. If both $q>0$ and $y_1>0$ then $\partial^2C/\partial\theta\partial q\leq 0$ and $\partial^2C/\partial\theta\partial y_1\leq 0$ by (1)-(3).

[9] Fixed-costs scope economies normally require the use of cost-allocation rules which may well re-introduce variable-cost non separability as in the present setting. This is discussed with more details in Calzolari (2001).

[10] Second order conditions are assumed to hold for all firms in market U.

welfare function in case of no bundling restrictions (or integration) is

$$W^I(q,T,\theta) = V_R(q) - qp(q) + V_U(Y) - Yp_U(Y) + T + \alpha\left(\Pi^I + \sum_{i=2}^{n}\pi_i\right) \tag{7}$$

while in case of bundling restraints (or separation),

$$W^S(q,T) = V_R(q) - qp(q) + V_U(Y) - Yp_U(Y) + T + \alpha\left(\Pi^S + \sum_{i=1}^{n}\pi_i\right) \tag{8}$$

where in both cases the weight to profits is $\alpha < 1$, as it is usually assumed in regulation models to avoid the Loeb-Magat paradox.[11]

The regulator sets a welfare maximizing regulatory instrument $T(q)$ which is a function of observable production q in the regulated sector. By definition of unregulated market U, the institutional set-up is such that the regulator cannot explicitly control output y_1 and / or any y_i, $i = 2$, Y_1 (i.e. regulation cannot be conditioned one these variable).

As we have discussed in the introduction, the size of the economies of scope is generally a source of asymmetric information so that θ is private information of the multi-utility and neither the regulator, nor the competitors in the unregulated market know the exact value of θ. We assume there are no other pieces of private information. This is clearly a simplification as regulation of a traditional single-product firm is also often affected by informational issues. Nevertheless, we employ this assumption to single out the effects of asymmetric information issues explicitly related to economies of scope and to the complexity of integrated multi-utility firms. For simplicity, we assume θ can take two values, i.e. $\theta \in \Theta \equiv \{\underline{\theta}, \bar{\theta}\}$ with $\nu = \Pr(\theta = \bar{\theta}) = 1 - \Pr(\theta = \underline{\theta})$ and $0 \leq \underline{\theta} \leq \bar{\theta}$. High economies of scale correspond to $\theta = \bar{\theta}$ and low ones to $\theta = \underline{\theta}$. For future reference, we will indicate the expected economy of scope with $\theta^e \equiv v\overline{\theta} + (1-v)\underline{\theta}$.

The timing of the game is the following.

1. The regulator decides and publicly announces whether to impose bundling restrictions (the separation regime) or not (the integration regime).

2. The regulator sets and publicly announces the (welfare maximizing) regulatory contract associated to the regime chosen at $t = 1$.

3. The multi-utility decides whether to be active in one or both markets and regulation is publicly enforced.

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

[11] In this paper we do not discuss the possibility that the regulator uses different weights to profit of regulated and unregulated firms. In a different context of regulation, this is analyzed in Calzolari and Scarpa (2001).

Note that the regulatory contract anticipates the determination of the equilibrium in the competitive sector. This setting can be justified on the ground that regulation usually follows procedures and activities which are more complicated to modify than private firms' price decisions.

Before proceeding with the analysis it is useful to notice that this model is isomorphic to one where the regulator's decision at $t = 1$ consists in banning or not multi-utility firms *strictu-sensu*. Indeed, imposing unbundling of activities is equivalent to banning integrated multi-utility firms and having a single firm that uniquely serves market R earning profits $\Pi^S(q)$ and a distinct firm with profit π_1 (together with other $n-1$ firm) in market U. On the contrary, with no bundling restrictions, it is as if the regulator let an integrated (multi-utility) firm earning profits Π^I. By properly adjusting the number of active firms in market U, the two interpretations lead exactly to the same model as the one presented in this section. For this reason, in the following we will refer to "imposing unbundling" as a synonymous for "imposing separation" and "allowing bundling" for "allowing integration". Independently of the regulatory regime at $t = 1$, the number of active firms in the unregulated sector remains constant and equal to n with both interpretations.[12]

3 Benchmark cases

In this section we introduce two benchmarks, which will help to discuss the pros and cons of bundling in the presence of asymmetric information. We first analyze the case where integration is not allowed, and then we study the case with integration and full information.

Optimal regulation with unbundling In our model asymmetric information matters only in case of bundling because the economies of scope parameter θ is the only source of uncertainty. Hence, the regulated firm's profit in sector R with unbundling is simply (6). Firm i's equilibrium output in the unregulated sector U can be defined as $y_i^S \equiv y_i(0,\theta)$ which depends neither on θ nor on q. In this case equilibrium profits in sector U are then

$$\pi^S \equiv \pi_i\left(y_i^S, Y_{-i}^S\right) \geq 0, \text{ for } i = 1, ..., n.$$

and welfare (8) becomes

$$V_R(q) - C(q) + V_U\left(Y^S\right) - nC\left(y^S\right) - (1-\alpha)\left[\Pi^S + n\pi^S\right]. \quad (9)$$

The regulator maximizes (9) with respect to q and T, subject to the participation constraint of the regulated firm,

$$\Pi^S + \pi^S \geq \pi^S$$

[12] If integration / bundling entailed an increase (reduction) in the number of firms active in U, then we would have a "trivial" competitive effect in favour of (against) integration / bundling. By keeping constant n independently of the regime we thus avoid this effect.

because, otherwise, the firm may prefer to serve only market U.[13] It is then immediate that the regulator optimally sets T so that the participation constraint binds, and the regulated firm earns no additional profits with respect π^S earned in the unregulated sector, i.e. $\Pi^S = 0$. It follows that regulation is efficient, the optimal quantity q^S is such that price in the regulated sector is equal to marginal cost, i.e. $p(q^S) = \frac{\partial C(q^S)}{\partial q}$ and together with the tariff T^S, the firm's profit is zero. For future reference we indicate this optimal regulation contract with separation with $\mathcal{C}^S \equiv (q^S, T^S)$ and the associated social welfare as

$$W^S(\mathcal{C}^S) = V_R\left(q^S\right) - C\left(q^S\right) + V_U\left(Y^S\right) - nC\left(y^S\right) - (1-\alpha)n\pi^S.$$

Multi-utility regulation with full information Assume now that the multi-utility is allowed to bundle activities and the regulator and rival firms are fully informed on scope economies θ. Optimal regulation should now anticipate the outcome in the unregulated sector. The following system of first order conditions

$$\begin{array}{l} \frac{\partial \pi_i(y_i, Y_{\_i})}{\partial y_i} = 0, \text{ for } i = 2, ..., n \\ \frac{\partial \Pi^I(y_1, Y_{\_1}, q; \theta)}{\partial y_1} = 0 \end{array}$$

gives the market equilibrium outputs $y_1(q,\theta)$, $y_j\left(q,\theta\right)$ with $j = 2, ..., n$ in the competitive sector. Exploiting symmetry for unregulated firms we have $y_i\left(q,\theta\right) = y\left(q,\theta\right)$, $Y_{\_1}\left(q,\theta\right) = (n-1)y\left(q,\theta\right)$ so that profits become

$$\begin{array}{l} \pi^I\left(q,\theta\right) = \pi_i\left[y_i\left(q,\theta\right), Y_{\_i}\left(q,\theta\right)\right], \text{ for } i = 2, ..., n \\ \Pi^I\left(q,\theta\right) = \Pi^I\left[q, y_1\left(q,\theta\right), Y_{\_1}\left(q,\theta\right); \theta\right] \end{array}$$

For future reference we note that the presence of economies of scope implies

$$\begin{array}{l} \frac{\partial y_1(q,\theta)}{\partial q} \geq 0, \quad \frac{\partial y(q,\theta)}{\partial q} \leq 0, \quad \frac{\partial \pi^I(q,\theta)}{\partial q} \leq 0 \\ y_1\left(q,\theta''\right) \geq y_1\left(q,\theta'\right), \quad y\left(q,\theta''\right) \leq y\left(q,\theta'\right) \text{ for any } \theta'' \geq \theta' \end{array}$$

Welfare can then be rewritten as

$$\begin{aligned} W^I\left(q,\theta\right) = \quad & V_R\left(q\right) + V_U\left[Y\left(q,\theta\right)\right] - C\left[q, y_1\left(q,\theta\right);\theta\right] - (n-1)C\left[y\left(q,\theta\right)\right] + \\ & -(1-\alpha)\left[\Pi^I\left(q,\theta\right) + (n-1)\pi^I\left(q,\theta\right)\right] \end{aligned} \quad (10)$$

For a given (and known) θ, the regulator maximizes (10) with respect to q subject to the

[13] With a strict interpretation of separation, the participation constraint would have been $\Pi^S\left(q\right) \geq \max\{0, \pi^S\}$ with the understanding that if the firm decides to be active uniquely in market U, it does so by acquiring one of the n existing firms, so that the number of active firms in U is always n (on and off-equilibrium). Similarly, profit $\Pi^S\left(q\right)$ can also be seen as the profit the firm obtains when uniquely operates in market R.

multi-utility's participation constraint

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

which assures that the multi-utility prefers to serve both markets instead of serving only one of them, market U leading to profit π^S or market R with profit Π^S which we know is nil from the previous analysis. Knowing the value of θ, it is optimal for the regulator to set the tax T such that the participation constraint binds for any θ and no extra-profits are given to the multi-utility, i.e. $\Pi^I(q,\theta) = \pi^S$. Hence, for any θ, the optimal quantity with full information and integration $q^I_{FI}(\theta)$ is such that

$$p_R(q^I_{FI}(\theta)) = SMC\left[q^I_{FI}(\theta), y_1(q^I_{FI}(\theta),\theta), y(q^I_{FI}(\theta),\theta),\theta\right]$$

where

$$\begin{aligned} SMC\left[q, y_1(q,\theta), y(q,\theta),\theta\right] &\equiv \partial W^I\left(q, y_1(q,\theta), y(q,\theta),\theta\right)/\partial q \\ &= \tfrac{\partial C}{\partial q} - \left[\left(p_U - \tfrac{\partial C}{\partial y_1}\right)\tfrac{\partial y_1}{\partial q} + (n-1)\left(p_U - \tfrac{\partial C}{\partial y}\right)\tfrac{\partial y}{\partial q} - (1-\alpha)(n-1)\tfrac{\partial \pi^I}{\partial q}\right] \end{aligned} \quad (11)$$

is the *social marginal cost* of q. This optimality condition shows that the price should not be equal to the marginal cost $\partial C/\partial q$ for three factors. The first two terms in the square bracket indicate that the regulated quantity should control also the distortions (or price-cost margins) in the unregulated sector which are weighted by the impact the regulated output has on individual firm's output in that sector. Note that $\frac{\partial p_U}{\partial q}(= p'_U\frac{\partial(y_1+(n-1)y)}{\partial q}) < 0$ implies $(n-1)\left|\frac{\partial y}{\partial q}\right| < \frac{\partial y_1}{\partial q}$ and we also have $p_U - \frac{\partial C}{\partial y_1} > p_U - \frac{\partial C}{\partial y}$ (because $\frac{\partial C}{\partial y_1} \leq \frac{\partial C}{\partial y}$) so that the first two terms in the square bracket are positive. These terms can be also rewritten as

$$p_U\left[\frac{\partial y_1}{\partial q} + (n-1)\frac{\partial y}{\partial q}\right] - \left[\frac{\partial C}{\partial y_1}\frac{\partial y_1}{\partial q} + \frac{\partial C}{\partial y}(n-1)\frac{\partial y}{\partial q}\right]$$

showing that the regulator is induced to increase q because by so doing it increases consumption Y in market U which is socially sub-optimal due to oligopolistic competition (the first term in the above expression) and also induces a better and less costly allocation of production in the sector U where the multiutility is the most efficient firm (the second term). The third term in (11) is also clearly positive and indicates an additional reason to give up standard allocative efficiency in the regulated market because of a distributional concern. By inducing the regulated firm to produce more in the market R, the regulator reduces the profits of other firms in the unregulated market (because $\frac{\partial \pi^I}{\partial q} < 0$), thus increasing social welfare. Hence, the entire square bracket in (11) is positive thus indicating that controlling for the unregulated market, the optimal q is increased with respect to separation. Note also that if market U were perfectly competitive then clearly $SMC[.] = \partial C/\partial q$. For the sake of concreteness in the following we will assume that $SMC[.] \geq 0$ and a larger θ reduces $SMC[.]$, as one should expect except for anomalous and uninteresting cases. All this is summarized in the following.

Remark 1 *With integration and full information, the optimal quantity in the regulated market* q_{FI}^{I} *is larger (the price* p_{FI}^{I} *is smaller) than with separation and* $\overline{q}_{FI}^{I} \geq \underline{q}_{FI}^{I}$, $\overline{p}_{FI}^{I} \leq \underline{p}_{FI}^{I}$.

Consumers in the regulated market pay a lower price with a multi-utility firm for two reasons. First because integration reduces marginal costs. Second, the optimal regulated price is meant to compensate distortions emerging in the unregulated market because competition is not sufficient to eliminate inefficient price-cost margins. In this respect, the regulator makes consumers in the regulated market pay less than the marginal cost, thus generating a cross-subsidy to the regulated market. This result reflects a departure from marginal cost pricing which 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. For future reference we indicate with $\mathcal{C}_{FI}^{I} = \left\{\left(q_{FI}^{I}(\theta), T_{FI}^{I}(\theta)\right)\right\}_{\theta\in\Theta}$ the optimal regulatory contract and with W_{FI}^{I} the welfare with bundling (i.e. with an integrated multi-utility) when the regulator and all the firms are fully informed about the multi-utility's cost structure.

4 Regulation of an integrated multi-utility

Let us now turn to the situation where the level of scope economies θ is private information of the multi-utility firm, and neither the regulator, nor the competitors in market U know it.

Recall first that - as already argued - the regulator acts before competition takes place in sector U, and therefore, she cannot use the observation of production levels in the unregulated sector to infer any information on θ. Hence, being the regulator uninformed on θ, we can rely on the Revelation Principle and we assume that the regulator designs a menu of contracts $\mathcal{C} = \left\{\left(q(\theta), T(\theta)\right)\right\}_{\theta\in\Theta}$ so that (i) she maximizes the expected social welfare, (ii) the multi-utility prefers serving the regulated sector and is induced to truthfully announce the level of scope economies. Thus, when the firm selects the regulatory contract $(q\left(\hat{\theta}\right), T\left(\hat{\theta}\right))$ by announcing $\hat{\theta}$, it (privately) informs the regulator on the true value θ.

Unregulated firms in sector U do not observe communication between the regulator and the multi-utility. However, they can profit of the observability of the regulatory contract and its realization in updating their beliefs on θ. More precisely, knowing regulation $\mathcal{C}$, firms may obtain information on θ by simply observing the (implemented) regulated price $\widehat{p}$ or, equivalently, the quantity $\widehat{q}$.[14] This is an important *informational externality* of regulation which allows the competitors to update their beliefs on the level of the scope economies conditional, say, on $\widehat{q}$, i.e. $\Pr(\theta|\widehat{q})$ and accordingly set their output in the unregulated market. It is important to realize also that this informational externality in turns affects the regulated firm's incentives to truthfully report the value of the parameter θ, as we will discuss in the sequel.

[14]The implemented contract $(\widehat{q}, \widehat{p})$ is clearly public information for consumers in market R and it is thus reasonable that also the rivals observe $(\widehat{q}, \widehat{p})$ (and observability of T is irrelevant). Furthermore, the decision to enter sector R does not provide information, because regulation grants any θ a profit at least as large as π^{S} (see below). We also implicitly assume that the multi-utility cannot credibly communicate the true θ to the rivals.

Given the (truthful) announcement of economies of scope, the competitive market game may or may not be one of complete information, depending on whether or not the updating of the rivals' expectations about the multi-utility's cost leads to perfect information. More precisely, if the optimal regulatory contract contemplates *discriminatory regulation* (i.e. a "screening" contract) with different quantities (and prices) for different cost announcements, the updating process is perfect so that $E(\theta|q(\theta)) = \theta$. On the contrary, in case the regulator prefers *uniform regulation* where quantity does not depend on the firm's type (i.e. a "pooling" contract) then, unregulated competitors are not able to perform any updating of beliefs so that in this case $\Pr(\theta|q(\theta)) = \Pr(\theta)$ and $E(\theta|q(\theta)) = \theta^e$.[15]

This description of beliefs of rival firms allows to illustrate the Bayesian equilibrium in the unregulated market where, for any $\widehat{q}$, outputs satisfy the following set of necessary conditions,

$$\begin{array}{l} \frac{\partial}{\partial y_i} E_\theta \left[\pi_i(y_i, Y\_i)|\widehat{q} \right] = 0, \text{ for } i = 2, ..., n \\ \frac{\partial}{\partial y_1} \Pi^I(\widehat{q}, y_1, Y\_1; \theta) = 0, \text{ for } \theta \in \Theta \end{array}$$

where $E_\theta \left[\pi_i(y_i, Y\_i)|\widehat{q} \right]$ is rivals' expected profit with expectation over θ, conditional on information provided by $\widehat{q}$. We denote with $y_1(\widehat{q}, \theta, v(\widehat{q}))$ the equilibrium output in the competitive market for the multi-utility producing a regulated output $\widehat{q}$ with (true) scope economies θ and when the rival firms' updated beliefs are $v(\widehat{q}) = \Pr(\overline{\theta}|\widehat{q})$ $(= 1 - \Pr(\underline{\theta}|\widehat{q}))$. Similarly, let $y(\widehat{q}, v(\widehat{q}))$ be the rivals' output (which clearly does not depend on the true level of scope economies). In addition to the comparative statics illustrated in section 3, it is interesting to notice that inducing rivals to believe that the level of scope economies is high, the multi-utility is able to increase its output, i.e. $y_1\left(\widehat{q}, \widehat{\theta}, v\right)/\partial v \geq 0$. Similarly, if the rivals in that market believe that the regulated firm has a large cost advantage, they reduce their output, i.e. $\partial y(\widehat{q}, v)/\partial v \leq 0$. Consistently with our notation, we will denote with $y_1\left(\widehat{q}, \widehat{\theta}, 1\right)$ and $y_1\left(\widehat{q}, \widehat{\theta}, 0\right)$ (similarly also for $y(\widehat{q}, v)$) the cases where beliefs updating in market U is perfect and rivals believe that the level of scope economies is respectively $\overline{\theta}$ or $\underline{\theta}$.

Consider now a multi-utility with scope economies θ, which declares $\widehat{\theta}$ and gets the contract $(\widehat{q}, \widehat{T}) \in \mathcal{C}$. This firm obtains a profit

$$\begin{array}{l} \Pi^I\left(\widehat{\theta}, \theta\right) = \widehat{q} p_R(\widehat{q}) + y_1(\widehat{q}, \theta, v(\widehat{q}))\, p_U\left[y_1(\widehat{q}, \theta, v(\widehat{q})) + (n-1) y(\widehat{q}, v(\widehat{q}))\right] + \\ \quad - C\left[\widehat{q}, y_1(\widehat{q}, \theta, v(\widehat{q})); \theta\right] - \widehat{T} \end{array}$$

Let us also denote by $\Pi^I(\theta)$ the (equilibrium) profit when the firm announces the true value of the economies of scope (i.e., $\Pi^I(\theta) = \Pi^I\left(\widehat{\theta}, \theta\right)$ with $\widehat{\theta} = \theta$). We are now in a position to state the

[15] Here we allow only for deterministic regulatory contracts so that updating is either prefect or absent. The regulator could better control the informational externality using a stochastic contract and a specific disclosure policy. A complete analysis of this type with a principal who screens and signals private information to third parties is in Calzolari and Pavan (2005). We avoid this complication and discuss this extension in Section 7.

regulatory problem with asymmetric information and bundling of activities as follows

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

where the incentive compatibility constraint $IC(\theta)$ assures that the firm with type θ prefers to report its type truthfully and the participation constraint $IR(\theta)$ has the same interpretation discussed in the previous benchmarks section.[16]

We now investigate the firm's incentives to announce the actual level of economies of scope. Incentive compatibility constraint for type θ can be rewritten as follows

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

where, for any θ and $\widehat{q}$,

$$\Pi_U\left(\widehat{q},\theta,v(\widehat{q})\right)\equiv y_1\left(\widehat{q},\theta,v(\widehat{q})\right)\ p_U\left[y_1\left(\widehat{q},\theta,v(\widehat{q})\right)+(n-1)y\left(\widehat{q},v(\widehat{q})\right)\right]-\left[C\left[\widehat{q},y_1\left(\widehat{q},\theta,v(\widehat{q})\right);\theta\right]-C\left[\widehat{q},0;\theta\right]\right]. \tag{12}$$

can be seen as the profit earned in the unregulated market by the multi-utility with scope economies θ producing $\widehat{q}$ in sector R, and similarly for $\Pi_U\left(\widehat{q},\widehat{\theta},v(\widehat{q})\right)$.[17] Hence, with a more compact notation, constraints $IC(\overline{\theta})$ and $IC(\underline{\theta})$ become

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

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 a firm with large scope economies $\overline{\theta}$ obtains with respect to a firm with low scope economies $\underline{\theta}$ when they both produce the same regulated output q. Notice that, for a given level of q and beliefs $v(q)$, larger economies of scope imply larger profit in the unregulated market Π_U, so that $\Delta_\theta\Pi_U\left(q,v(q)\right)\geq 0$.[18]

As in standard models of regulations with asymmetric information, more efficient firms (i.e. those with lower production costs) have incentives to understate their level of scope economies and mimic firms with $\theta=\underline{\theta}$ in order to obtain more favorable regulation. Formally, this *cost-efficiency*

[16] Note that the cost announcement $\widehat{\theta}$ impacts $\Pi^I\left(\widehat{\theta},\theta\right)$ uniquely through regulator's instruments $(\widehat{q},\widehat{T})$ also when it affects rivals' beliefs $v(\widehat{q})$. Hence, with deterministic contracts one can rely on the standard proof of the Revelation Principle and show that direct mechanisms are without loss, as stated in the texts.

[17] Note that being $C\left[\widehat{q},0;\widehat{\theta}\right]=C\left[\widehat{q},0;\theta\right]$, the cost in Π_U can be written in terms of incremental costs $C\left[\widehat{q},y_1\left(\widehat{q},\theta,v(\widehat{q})\right);\theta\right]-C\left[\widehat{q},0;\theta\right]$.

[18] Indeed, for a given level of q with beliefs $v(q)$, competitors' reaction $y\left(q,v(q)\right)$ is unaffected by the true level of θ.

effect of cost announcement is captured in $\Delta_\theta \Pi_U \left(\underline{q}, v(\underline{q})\right)$ by the difference $C\left(\underline{q}, y_1; \overline{\theta}\right) - C\left(\underline{q}, y_1; \underline{\theta}\right)$. Indeed, if firm with type $\overline{\theta}$ mimics type $\underline{\theta}$, it can produce the same regulated quantity $\underline{q}$ with a cost saving corresponding the previous difference. Note that, as we will discuss in Section 6, contrary to standard models of regulation the cost-efficiency effect here also depends on the quantity produced for the unregulated market y_1 because scope economies are larger the larger is y_1.

With bundled activities run by the multi-utility, we have also two additional effects of reporting θ linked to the informational externality from the regulated market towards the unregulated one. A *direct strategic effect* works through the multi-utility cost reduction that the rivals anticipate when the regulated firm produces a larger q, for given level of θ. Indeed when they observe that the regulated firm produces a large quantity q, then they anticipate that the cost advantage of the multi-utility is large, independently of the level of θ. This effect creates incentives for the multi-utility with low (high) scope economies to mimic a high (low) type if regulation is such that $\overline{q} \geq (\leq) \underline{q}$. Note that this effect, would affect rivals' behavior independently of the information they have about θ and is strictly related to the relationship between $\overline{q}$ and $\underline{q}$. In addition, a *beliefs-strategic effect* also exists which is the consequence of asymmetric information in market U and would not exist if rivals knew θ. The multi-utility would like to convince the rivals that scope economies are large so that whenever the regulated quantities are such that $\overline{q} \neq \underline{q}$, a multi-utility with low scope economies is tempted to overstate θ, produce $\overline{q}$ and let the rivals believe that indeed it has large scope economies. This anti-competitive effect operates independently of any relationship between $\overline{q}$ and $\underline{q}$ and increases the incentive of a multi-utility with low scope economies to mimic a type $\theta = \overline{\theta}$.

As we now illustrate, these three effects have notable impact on optimal regulation. In a standard analysis of regulation with asymmetric information, the regulator must simply take care that the most efficient firm (here type $\overline{\theta}$) does not mimic less efficient ones (here type $\underline{\theta}$). Indeed, type $\underline{\theta}$ has no incentive to present itself as a more efficient firm by announcing a type $\overline{\theta}$, whenever in this case it would be required to produce a larger output $\overline{q} \geq \underline{q}$.[19] Notably, this is no longer true in the case of multi-utility regulation. The monotonicity condition on regulated quantities $\overline{q} \geq \underline{q}$ does not guarantee anymore that the low scope economies firm prefers not to mimic the firm with large scope economies. Indeed, we now know that the direct strategic effect increases that type's incentives to mimic exactly because $\overline{q} \geq \underline{q}$. Moreover, as compared to a case with informed rivals, also the beliefs-strategic effect induces this type of behavior. Hence, in principle, optimal regulation may well require either a reversed monotonicity, i.e. $\overline{q} < \underline{q}$, or a uniform regulatory policy where the regulator prefers not to discriminate with respect to the level of scope economies, i.e. $\overline{q} = \underline{q}$, so that the observed regulated quantity or price is totally uninformative to competitors.

The following proposition describes optimal regulation by formally taking into account for these novel effects on regulation introduced by the multi-utility firm.

[19]This happens because, announcing $\overline{\theta}$ and being required to produce such a large quantity $\overline{q}$, an inefficient firm faces very high production costs and low profits.

Proposition 1 *Let* $SMC(q,\theta,v) \equiv SMC(q, y_1(q,\theta,v), y(q,v), \theta)$ *and, for any* θ*, let* $\hat{q}(\theta)$ *be such that*

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

with $\mathcal{I}_\theta = 1$ *if* $\theta = \overline{\theta}$ *and zero otherwise.*

Optimal regulation is discriminatory *with quantities* $q^*(\theta) = \hat{q}(\theta)$ *for any* θ*, if*

$$\Delta_\theta \Pi_U(\overline{q}^*, 1) \geq \Delta_\theta \Pi_U\left(\underline{q}^*, 0\right). \tag{15}$$

Otherwise, a uniform *regulatory policy is optimal with* $\overline{q}^* = \underline{q}^* = \widetilde{q}$ *where*

$$p(\tilde{q}) = E_\theta\left[SMC(\tilde{q},\theta,v)\right] + (1-\alpha)\frac{v}{1-v}\frac{\partial \Delta_\theta \Pi_U(\widetilde{q},v)}{\partial q}. \tag{16}$$

In both cases, multi-utility's profit is $\Pi^I(\theta) = \pi^S + \mathcal{I}_\theta \Delta_\theta \Pi_U\left(\underline{q}^*, v\left(\underline{q}^*\right)\right)$

The three effects that we have highlighted above explain why, instead of the standard monotonicity condition on quantities, the incentives of the multi-utility with low scope-economies are controlled by the more general condition (15). It also shows that bundling activities may make too costly for the regulator to set a discriminatory regulation. Finally, notwithstanding type $\underline{\theta}$' stronger incentives to overstate its scope economies, this firm earns no extra profits with respect to π^S, whilst the multi-utility with large scope economies earns an informational rent $\Delta_\theta \Pi_U\left(\underline{q}^*, v\left(\underline{q}^*\right)\right)$ which is positive irrespectively of the regulatory policy regime. As it can be seen from the pricing conditions (14) and (16), this informational rent introduces a distortion in regulated quantities (and prices). This is the case when $\theta = \underline{\theta}$ with discriminatory regulation and it always happens with optimal uniform policy. The reason for this distortion is standard in models of regulation with asymmetric information and is the consequence of regulator's need to guarantee a sufficiently large rent to the efficient firm (type $\overline{\theta}$) to avoid it prefers to mimic an inefficient firm. However, also with this respect bundling activities by a multi-utility firm may have a relevant impact as discussed in the following Corollary.

Corollary 1 *(i) With discriminatory regulation and large economies of scope regulated price and quantities are undistorted (i.e.* $\overline{q}^* = \overline{q}^I_{FI}$*,* $\overline{p}^* = \overline{p}^I_{FI}$ *). With small economies of scope, optimal regulation may require upward (i.e.* $\underline{q}^* \geq \underline{q}^I_{FI}$*,* $\underline{p}^* \leq \underline{p}^I_{FI}$ *) or downward distortions (i.e.* $\underline{q}^* \leq \underline{q}^I_{FI}$*,* $\underline{p}^* \geq \underline{p}^I_{FI}$*) as compared with full information. Furthermore, either upward monotonicity* $\overline{q}^* > \underline{q}^*$ *or downward monotonicity are admissible.*

(ii) With uniform regulation price and quantity are generically distorted with respect to full information.

Bundling activities in the two markets has several effects on regulation with asymmetric information on scope economies. As already discussed, when optimal regulation is discriminatory, it also informs rival firms in the unregulated market about the level of scope economies so that multi-utilities with low scope economies may find desirable to mimic firms with high scope economies in order to influence rival firms's reaction in the unregulated market. If this is the case, the regulator cannot adopt a discriminatory regulation that would serve as an informational channel and she is obliged to restraint to uniform regulation. Furthermore, incomplete knowledge by the regulator may induce either downward or upward distortion of regulated quantity with lo scope economies with respect to optimal regulation with full information and, possibly also "reverse monotonicity", i.e. $\overline{q}^* < \underline{q}^*$.

5 The desirability of horizontal integration

We consider first the benchmark where both *the regulator and the rivals know the level of scope economies*. When the multi-utility may bundle its activities and complete integration is allowed, several effects emerge as compared with unbundling. These can be illustrated by inspecting the social welfare written as follows.

$$\begin{aligned} W^I_{FI}(q,\theta) = \quad & V_R(q) + V_U[Y(q,\theta)] - C[q, y_1(q,\theta);\theta] - (n-1)C[y(q,\theta)] + \\ & -(1-\alpha)\left[\pi^S + (n-1)\pi^I(q,\theta)\right] \end{aligned}$$

First, the multi-utility is more efficient in its activities in the unregulated market than it would be were it obliged to unbundle. Indeed, total industry costs are lower than with unbundling and consumers' surplus in the unregulated market increases because the presence of a more efficient firm induces larger production and a lower price.[20] Second, the overall profits earned by the firms in the two industries are reduced with integration of multi-utility activities. In fact, total profits earned by the firms in the two markets are $\pi^S + (n-1)\pi^I(q,\theta)$ with integration and $\pi^S + n\pi^S$ with unbundling. On one side rivals face a tougher competitor in case of bundling and earn smaller profits $\pi^I(q,\theta) \leq \pi^S$. On the other side, the regulator is fully informed on the level of scope economies and is able to appropriate the additional multi-utility's profits. Third, bundling - with full information - necessarily produces a larger net surplus in the regulated sector as well because of scope economies and undistorted regulation. All the three effects of integration of multi-utility's activities are positive and increase social welfare W, so that when all players are fully informed, there is no ambiguity in the decision whether or not to allow a joint management of the multi-utility firm's activities.

It is important to note that this result also extends to the case where the rivals are not informed on θ, as long as the regulator is fully informed. In fact, regulated quantity and price convey all the information on θ because we know that (generically) $\overline{q}^I_{FI} \neq \underline{q}^I_{FI}$ and $\overline{p}^I_{FI} \neq \underline{p}^I_{FI}$ so that the rivals can simply infer the true value of θ by inspecting the implemented regulatory policy. Competition

[20] Even if we do not explicitly model this possibility, note that this holds true even if the efficiency of the multi-utility induces some competing firms to exit. Exit of rivals due to integration of activities of the multi-utility will be discussed in the sequel.

in the unregulated market then takes place under full information thanks to this informational externality and we are back to the previous case where all players are fully informed.[21]

Remark 2 *A fully informed regulator prefers the multi-utility firm to operate by bundling its activities in the two sectors, independently of the information of rivals firm in the unregulated market.*

The analysis on the desirability of bundling is more subtle when the regulator does not know the level of scope economies. In fact, when integration generates asymmetric information then one needs to consider additional effects with respect to those illustrated above. First, we know that the regulator must allow the firm (with large scope economies) to retain some extra-rents, in order to induce information revelation. Second, asymmetric information generates inefficiencies in regulatory process. As shown in Proposition 1 and Corollary 1, the regulated price systematically entails a reduction in allocative efficiency when economies of scope are small and this may also emerge with large scope economies in case of uniform regulation.

Consider now the following reasoning. Imagine that with integration the regulator simply offers the multi-utility exactly the same regulatory contract $\mathcal{C}^S$ that she designs in case of unbundling and separation of activities. Clearly, the consumers' surplus in the regulated sector is unaffected with respect to the case of separation because the firm produces exactly the same quantity q^S. Moreover, the multi-utility obtains a larger profit induced by (large or small) scope economies. Finally, the unregulated market simply becomes more efficient because one of the active firms, namely the multi-utility, has now lower costs. Hence, this reasoning seems to point out that the overall welfare in the two markets increases as a consequence of integration even if $\mathcal{C}^S$ is not the optimal regulatory contract in case of integration. Unfortunately, in general this claim is fallacious and needs an important qualification to be true, as shown in the following lemma.

Lemma 1 *Assume the rival firms in the unregulated market are fully informed then bundling and integrating activities into a multi-utility is socially desirable.*

The proof of this Lemma is immediate. When the rival firms know the level of scope economies independently of the information disclosed by the regulatory contract $\mathcal{C}$, then our previous reasoning holds. Implementing the potentially sub-optimal contract $\mathcal{C}^S$ designed for separation suffices to generate a larger social welfare when the multi-utility can integrate its activities.[22]

However, as we have highlighted in the introduction, rival firms often claim their impossibility to ascertain the exact level of scope economies of the multi-utility firm, as much as, regulators do. Note

[21] Note also that the desirability of integration in this case also holds if the regulator prefers to convey only partial information on θ to the unregulated market, for whatever reason. In fact, the welfare associated with full information disclosure is always attainable and we know this is larger than that with unbundling multi-utility's activities.

[22] This idea also holds if some rivals are obliged to exit the market when the multi-utility can profit of scope economies. Indeed, if a rival exits with quantity competition, this is because the multi-utility is more efficient and total output Y increases.

that in the reasoning that lead to Lemma 1, the optimal contract $\mathcal{C}^S$ designed for unbundled and separated activities provides no information at all on the level of scope economies θ to the rivals so that, if the regulator employed $\mathcal{C}^S$, competition in the unregulated market would take place under asymmetric information. With this respect it is well known that the efficiency properties of an oligopolistic market with asymmetric information among competing firms are ambiguous. The literature on information sharing in oligopolies provides some useful indications with this respect.[23] Sakai (1985) considers an oligopoly with n quantity-competing firms, linear demand and costs. He shows that, comparing with the case of full information among firms, if firms are uninformed on rivals' costs then consumer surplus may be larger, total profits smaller (any firm individually would like to inform rivals) and, more importantly, welfare is smaller. Coming back to our setting, this shows that employing the suboptimal contract $\mathcal{C}^S$ may well induce a welfare reduction in the unregulated market, thus suggesting that bundling multi-utility's activities may entail a trade-off when rival firms are uninformed. The effect of bundling and integration may be then negative, especially if the unregulated market is large relative to the regulated one. Hence, what can we say about the desirability of integrating activities into a multi-utility firm when both the regulator and the rival firms do not know the exact level of scope economies?

Clearly, the answer to this question cannot rely on the analysis of contract $\mathcal{C}^S$ designed for the case of separation and must be based on the (fully) optimal regulatory contract $\mathcal{C}^I$ through which the regulator can explicitly control all the pros and cons of integration. We will preform this analysis in the next section with an explicit model.

6 A model with an explicit solution

Consider the following model with (inverse) demand functions,

$$p_R = \gamma_R - q, \qquad p_U = \gamma_U - Y \tag{17}$$

and cost function

$$C(q, y_1; \theta) = c(q + y_1) - \theta q y_1. \tag{18}$$

where c is a positive constant. It is immediate to verify that (18) verifies all our conditions (1)-(4).

When the regulated firm cannot bundle and integrate its activities any firm produces $y^S = \frac{\gamma_U - c}{n+1}$ and obtains profits $\pi^S = \left(\frac{\gamma_U - c}{n+1}\right)^2$. Moreover, regulation in market R takes place under full information, with optimal price $p(q^S) = c$, quantity $q^S = \gamma_R - c$ and the regulated firm is left with profit π^S. Summarizing, the regulatory contract in this case of unbundling or separation is

[23] See Vives (1999) for a comprehensive survey.

$\mathcal{C}^S \equiv (\gamma_R - c, -\pi^S)$ and total welfare,

$$W^S\left(\mathcal{C}^S\right) = \frac{(\gamma_R - c)^2}{2} + \left(\frac{\gamma_U - c}{n+1}\right)^2 \frac{n\,(2+n)}{2} - (1-\alpha)\,(n+1)\left(\frac{\gamma_U - c}{n+1}\right)^2$$

where the first term is welfare in sector R, the second that in sector U and the third is total profits in both markets.

6.1 Regulation and Integration

For given values of q and θ, let define with $ES\left[v\left(\widehat{q}\right)\right] := v\left(\widehat{q}\right)\overline{\theta}\overline{q} + (1 - v\left(\widehat{q}\right))\underline{\theta}\underline{q}$ the *expected value of economies of scope* inferred by rival firms when the multi-utility chooses a regulated output $\widehat{q}$. In particular, we have that when the regulatory policy is discriminating (i.e. $\underline{q} \neq \overline{q}$) then, if $\widehat{q} = \overline{q}$ it follows that $v\left(\overline{q}\right) = 1$ and $ES\left[v\left(\overline{q}\right)\right] = \overline{q}\overline{\theta}$; otherwise if $\widehat{q} = \underline{q}$ then $v\left(\underline{q}\right) = 0$ and $ES\left[v\left(\underline{q}\right)\right] = \underline{q}\underline{\theta}$. On the contrary, with a uniform policy $\widetilde{q}$ we have $v\left(\widetilde{q}\right) = v$ and $ES\left[v\left(\widetilde{q}\right)\right] = \widetilde{q}\theta^e$ where $\theta^e = v\overline{\theta} + (1-v)\widetilde{q}\underline{\theta}$.

Now, let $FE\left(\widehat{q}, \theta\right) \equiv v\left(\widehat{q}\right)\overline{\theta}\overline{q} + (1 - v\left(\widehat{q}\right))\underline{\theta}\underline{q} - \theta\widehat{q}$ be the *forecast error* on multi-utility' scope-economies incurred by the rival firms when the multi-utility chooses a regulated output $\widehat{q}$ and has a true level of scope economies θ. With discriminatory regulation we have

$$\begin{aligned}
&FE\left(\overline{q}, \overline{\theta}\right) = 0,\\
&FE\left(\overline{q}, \underline{\theta}\right) = \overline{q}\left(\overline{\theta} - \underline{\theta}\right) > 0,\\
&FE\left(\underline{q}, \underline{\theta}\right) = 0,\\
&FE\left(\underline{q}, \overline{\theta}\right) = -\underline{q}\left(\overline{\theta} - \underline{\theta}\right) < 0,
\end{aligned}$$

Clearly, if the announcement $\widehat{\theta}$ corresponds to the true level of scope economies $\widehat{\theta} = \theta$, then observing $\widehat{q}$ the rivals will make no error and $FE = 0$. On the contrary, the error may induce the rivals to over or under estimate scope economies.

Equilibrium outputs in the unregulated market can be then indicated as,[24]

$$\begin{array}{l}
y_1\left(\widehat{q}, \theta, v\left(\widehat{q}\right)\right) = \frac{\gamma_U - c + n\theta\widehat{q}}{n+1} + \frac{n-1}{2(n+1)} FE\left(\widehat{q}, \theta\right)\\
y\left(\widehat{q}, v\left(\widehat{q}\right)\right) = \frac{\gamma_U - c}{n+1} - \frac{1}{n+1} ES\left[v\left(\widehat{q}\right)\right] = \frac{\gamma_U - c - \theta\widehat{q}}{n+1} - \frac{1}{n+1} FE\left(\widehat{q}, \theta\right)\\
Y\left(\widehat{q}, \theta, v\left(\widehat{q}\right)\right) := y_1\left(q(\widehat{\theta}), \theta, v\left(q(\widehat{\theta})\right)\right) + (n-1) y\left(q(\widehat{\theta}), v\left(q(\widehat{\theta})\right)\right)
\end{array} \tag{19}$$

These expressions show that, when the rivals overestimate the expected scope economies so that $FE\left(\widehat{q}, \theta\right) \geq 0$, the multi-utility expands its production and the rivals contract theirs, and the opposite holds with underestimation.

[24] Second order conditions are verified.

Similarly, we can write multi-utility's profits Π_U in the unregulated market as follows,

$$\Pi_U(\widehat{q},\theta,v(\widehat{q})) = \frac{\left[2\left(\gamma_U - c + n\widehat{q}\theta\right) + (n-1)FE\left(\widehat{q},\theta\right)\right]^2}{4\left(n+1\right)^2} \tag{20}$$

which is increasing in the economies-of-scope parameter θ and in the rivals' error FE and the profit of the rivals is

$$\pi^I(\widehat{q},\theta,v(\widehat{q})) = \frac{\left(\gamma_U - c - ES\left[v\left(\widehat{q}\right)\right]\right)\left[2\left(\gamma_U - c - ES\left[v\left(\widehat{q}\right)\right]\right) + (n+1)FE\left(\widehat{q},\theta\right)\right]}{2\left(n+1\right)^2} \tag{21}$$

which is decreasing in the error. These expressions for outputs and profits all show that the multi-utility gains and the rivals lose when the latters overestimate the level of scope economies so that $FE(\widehat{q},\theta) \geq 0$ (and the opposite holds with underestimation).

As we emphasized in the previous analysis, letting the regulated firm to be active also in the competitive market has three main effects.

First, economies of scope arise from the integrated production. Second, the induced asymmetry of information between the regulator and the multi-utility firm adversely affects the regulatory process. Third and finally, uncertainty affects rival firms in the unregulated market as well. The market competitive game takes place under asymmetric information and multi-utility's cost announcement affects also the unregulated market.

Consider now the extra profit $\Delta_\theta\Pi_U\left(\underline{q},0\right)$ that the regulated firm with high scope economies earns when optimal regulation is discriminating, as illustrated in Proposition 1. In the current model this can be written as (see the Appendix)

$$\Delta_\theta\Pi_U\left(\underline{q},0\right) = \frac{\left[2\left(\gamma_U - c\right) + 2n\underline{q}\overline{\theta} + (n-1)FE\left(\underline{q},\overline{\theta}\right)\right]^2 - \left[2\left(\gamma_U - c\right) + 2n\underline{q}\underline{\theta}\right]^2}{4\left(1+n\right)^2}$$

which shows that the unregulated market U has several effects in this profit (and in the associated distortion that arises when $\theta = \underline{\theta}$, see the pricing condition (14)). As expected, type $\overline{\theta}$ is negatively affected by the fact that rivals are uniformed because type $\overline{\theta}$ would like to induce a positive forecast error on the part of its rivals and by mimicking type $\underline{\theta}$ it obtains exactly the opposite (indeed, $FE\left(\underline{q},\overline{\theta}\right) < 0$).

A deepen study of the function $\Delta_\theta\Pi_U$ allows us to further illustrate the properties of optimal regulation in the current model and to specialize our findings of Corollary 1.

Proposition 2 *Let demand and cost functions be defined by (17)-(18).*

(i) Optimal regulation is discriminatory with $\overline{q}^* > \underline{q}^*$ *and* $\underline{q}^I_{FI} > \underline{q}^*$.

(ii) The asymmetric-information distortion measured by $\underline{q}^I_{FI} - \underline{q}^*$ *increases with the dimension of the unregulated market* γ_U *and the number* n *of firms therein active.*

(iii) The multi-utility's profit increases with γ_U *and decreases with* n.

The linear quadratic model we are considering illustrates that the asymmetric information distortion $\partial\Delta_\theta\Pi_U/\partial q$ in the optimal pricing condition (14) is strictly positive (except in the uninteresting case with $\overline{\theta}=\underline{\theta}$) so that optimal regulation is discriminatory and involves distortion when $\theta=\underline{\theta}$. Furthermore, it is also interesting to illustrate how the unregulated market impacts on this distortion. Point (ii) in the proposition shows that the larger is market U, the stronger are the incentives of multi-utility with high scope economies to understate the level of scope economies. As discussed in Section 4, the standard cost-efficiency effect of scope economies announcement here depends also on output y_1 in the unregulated market. The larger is y_1 the larger is the scope economy $\theta q y_1$ and then also the cost saving of firm with $\theta=\overline{\theta}$ as compared with type $\theta=\underline{\theta}$. Hence, when y_1 is large, for example due to a large market U (i.e. γ_U is large), the regulator is obliged to leave a large profit $\Delta_\theta\Pi_U$ to type $\overline{\theta}$ and this also increases the distortion arising when scope economies are low. The effect of a larger n, or stronger competition in market U, is more complex as it can be grasped by the previous expression of $\Delta_\theta\Pi_U\left(\underline{q},0\right)$. Proposition 20 shows that the regulated multi-utility's (extra) profit decrease in n, as one may expect, but the asymmetric information distortion increases with n thus surprisingly showing that the consumers in the regulated market R are negatively affect by a more competitive unregulated market U.

We now turn to our unanswered question on the desirability of bundling and integrating multi-utilities' activities. Imagine the regulator offers the bundling multi-utility the regulatory contract $\mathcal{C}^S$ illustrated above for the case of separation and let us compare the welfare generated in this case with welfare that would arise with contract $\mathcal{C}^S$ but when unbundling or separation is indeed imposed. As discussed in the previous section, consumer surplus in the regulated market would be exactly the same so that the difference in welfare can be simply decomposed,

$$\begin{aligned}
&E_\theta[W(\mathcal{C}^S,\theta)]-W(\mathcal{C}^S)= \\
&\quad E_\theta\left[V_U\left(Y(\mathcal{C}^S,\theta)\right)-(n-1)c\times y\left(\mathcal{C}^S,\theta\right)-c\times y_1\left(\mathcal{C}^S,\theta\right)\right]-\left[V_U\left(Y^S\right)-nc(y^S)\right]+ \\
&\quad-(1-\alpha)\left[(n-1)\pi^I\left(\mathcal{C}^S,\theta\right)+\Pi_U\left(\mathcal{C}^S,\theta\right)-n\pi^S\right] \\
&\quad+E_\theta\left[B(\mathcal{C}^S;\theta)\right]
\end{aligned} \tag{22}$$

where $Y(\mathcal{C}^S,\theta)$, $y\left(\mathcal{C}^S,\theta\right)$, $y_1\left(\mathcal{C}^S,\theta\right)$ represent outputs obtained in (19) when the regulatory contract is $\mathcal{C}^S$ and the true level of scope economies is θ. Similarly, $\pi^I\left(\mathcal{C}^S,\theta\right)$ and $\Pi_U\left(\mathcal{C}^S,\theta\right)$ are obtained from (21) and (20) considering regulation $\mathcal{C}^S$. Finally, $B(\mathcal{C}^S;\theta)$ represents the cost saving induced by scope economies when regulation is $\mathcal{C}^S$ and non regulated output is $y_1\left(\mathcal{C}^S,\theta\right)$.

This expression for the difference in welfare unravels the negative effect induced in an unregulated market that operates under asymmetric information. Recall in fact that contract $\mathcal{C}^S$ does not disclose information about θ to the rivals and consider the second line in (22) that illustrates the difference in gross consumer surplus net-of-production costs in the unregulated market U. Assume for simplicity that $c=0$ so that the second line simply becomes,

$$E_\theta\left[V_U\left(Y(\mathcal{C}^S,\theta)\right)\right]-V_U\left(Y^S\right).$$

It is then possible to calculate total outputs under asymmetric information in our model with explicit solution and simply show that, as one would expect,[25]

$$Y(\mathcal{C}^S,\overline{\theta}) = Y\left(q^S,\overline{\theta},v\right) \geq Y^S$$

However, we also have that

$$Y^S \geq Y(\mathcal{C}^S,\underline{\theta}) = Y\left(q^S,\underline{\theta},v\right)$$

if, for example, $\underline{\theta}$ is sufficiently low or v sufficiently large.[26]

Let us comment on these two inequalities. When the rival do not know the value of θ and do not receive any information from the regulatory process, they act as if the multi-utility had a (expected) level of scope economies equal to $q^S\theta^e$. This implies that when the real value of θ is $\overline{\theta}$, the rival underestimate the scope economies and produce more than they would do knowing that $\theta = \overline{\theta}$. This ultimately induces an expansion of total production in sector U so that $Y(\mathcal{C}^S,\overline{\theta}) \geq Y^S$. However, when the rivals' estimation of θ is upward distorted because the true level of θ is $\underline{\theta}$ whilst they expect θ^e, then they reduce production. In this case, it may well happens that the contraction of total production of the $n-1$ rivals exceeds the expansion of the multi-utility and this induces a reduction of total production as compared with unbundling, i.e. $Y^S \geq Y(\mathcal{C}^S,\underline{\theta})$. This is indeed the case for example if $\underline{\theta} = 0$ or if v is sufficiently large.[27] Now, being the gross-consumer surplus a concave function of total output, it follows that the net effect of integration on consumer surplus (i.e. the term $E_\theta\left[V_U\left(Y(\mathcal{C}^S,\theta)\right)\right] - V_U\left(Y^S\right)$ in the previous expression (22)) is ambiguous because integration with asymmetric information in the unregulated market induces larger variability on consumption as compared with separation and this may ultimately harm welfare in the sector. This conclusion reinforces our concerns expressed at the end of Section 5 where we illustrated the need to rely on an explicit model for comparing integration with unbundling so as to explicitly contrast the several effects at play. This is done in the following Proposition.

Proposition 3 *Let demand and cost functions be defined by (17)-(18).*
Integration and bundling multi-utility's activities is always socially desirable.

To understand the logic behind the Proposition we note that the important reference point one should consider is that of optimal regulation with asymmetric information but where the rivals are fully informed on θ. Let indicate this policy with $\mathcal{C}'$. We know from Lemma 1 that bundling multi-utility's activities is desirable in that context and if one is able to show that when rivals are uninformed social welfare is even larger, then Proposition 3 immediately follows. To this end imagine to use the regulatory policy $\mathcal{C}'$ designed when the rivals are informed on θ, to the current

[25] Indeed we have $Y\left(q^S,\overline{\theta},v\right) \geq Y^S$ if $(n+1)\overline{q}\overline{\theta} - (n-1)ES\left[v\left(\widehat{q}\right)\right] \geq 0$.

[26] We have $Y^S - Y(\mathcal{C}^S,\underline{\theta}) = (n-1)v\overline{q}\overline{\theta} - \underline{q}\underline{\theta}\left[2+v(n-1)\right]$ which is certainly positive if $\underline{\theta} = 0$.

[27] Note that this uncertainty over θ may even induce some rivals to exit the market thus further reducing the number of active firms in the unregulated sector. Also note that total output reduction can never happen were the rivals fully informed on θ.

contest where rivals do not know θ. This policy is potentially suboptimal in this case, but it is still possible to prove that the associated welfare is indeed not smaller than that arising when rivals are fully informed so that the result follows.

To see this note that, as discussed above, when rival firms are uniformed information revelation by the multi-utility of type $\overline{\theta}$ is easier. A firm with high economies of scope induces a more aggressive behavior by the rivals if it selects a contract designed for a firm with low scope economies. This allows the regulator to reduce the profit of that type $\overline{\theta}$ and also the distortion on $\underline{q}$ as compared with the case where the rivals are informed on θ. On the other hand we also know that type $\underline{\theta}$ may profit from the rivals being uninformed thus making constraint $IC(\underline{\theta})$ more difficult to satisfy. The proof then shows that, this notwithstanding, regulation $\mathcal{C}'$ is incentive compatible also when applied to the current contest with uniformed rivals. Hence, the expected welfare when the rival firms are not informed on θ is (weakly) larger than that when they know θ.

Note that the logic behind this result seems more general than this explicitly calculable model may show. What makes the analysis more complex in the general setting is that the effect uninformed rivals on incentive compatibility is composite as we have discussed above. On one side it is positive for the regulator as for the incentives with type $\overline{\theta}$, but it is potentially negative with type $\underline{\theta}$. It is then difficult to generalize the fact that regulation $\mathcal{C}'$ remains incentive compatible also when rivals are uninformed and show that the cost of guaranteeing incentive compatibility for type $\underline{\theta}$ are sufficiently low.

6.2 Price competition

In this section we check the robustness of our analysis to a different form of competition in the unregulated market. Here we assume that in market U firms compete on prices for differentiated products. Let demand in the regulated and unregulated market be

$$p_R = \gamma_R - q, \qquad y_1 = \gamma_U - bp_1 + \sum_{i \neq 1} sp_i, \qquad y_i = \gamma_U - bp_i + \sum_{j \notin \{1,i\}} sp_j + sp_1$$

where we assume - as usual - that $b - (n-1)s > 0$.[28] Cost functions are the same as in section 6

The full information Nash-Bertrand equilibrium yields the following equilibrium prices

$$\begin{aligned} p_1^{FI} &= \tfrac{\gamma_U + bc}{2b-(n-1)s} - \tfrac{b(2b-(n-2)s)}{(2b+s)(2b-(n-1)s)} q\theta \\ p^{FI} &= \tfrac{\gamma_U + bc}{2b-(n-1)s} - \tfrac{bs}{(2b+s)(2b-(n-1)s)} q\theta \end{aligned}$$

where $2b - (n-2)s > 2b - (n-1)s > 0$. These prices show complementarity in price competition. Indeed, larger scope economies or regulated output reduce the costs of the multi-utility, its price p_1 and then also the prices p of $n-1$ (symmetric) rivals. It also follows that larger scope economies

[28] This system of demand for market U are derived from utility $V_U[y_1, y] = \mu(y_1 + (n-1)y) - \frac{1}{2}\beta\left(y_1^2 + (n-1)y^2\right) - \gamma(n-1)y_1 y$ where $\gamma_U = \frac{\mu}{\beta+(n-1)\sigma}$, $b = \frac{\beta+(n-2)\sigma}{(\beta+(n-1)\sigma)(\beta-\sigma)}$, $s = \frac{\sigma}{(\beta+(n-1)\sigma)(\beta-\sigma)}$.

or regulated output both increase multi-utility's and competitors' profits.

When, on the contrary, the cost parameter θ is private information of the multi-utility, competition in market U may take place under asymmetric information, depending on the bundling decisions and the associated regulatory policy. With a bundled multi-utility, rivals form their expectations on θ on the basis of the regulatory contract. Equilibrium prices are then as follows

$$\begin{aligned} p_1 &= p_1^{FI} - \tfrac{(n-1)s^2}{2(2b+s)(2b-(n-1)s)} FE\left(\widehat{q},\theta\right), \\ p &= p^{FI} - \tfrac{bs}{(2b+s)(2b-(n-1)s)} FE\left(\widehat{q},\theta\right). \end{aligned}$$

Contrary to quantity competition, if rivals expect larger economies of scope than real ones (i.e. $FE\left(\widehat{q},\theta\right) \geq 0$), then they reduce their price and, by complementarity, also the multi-utility reduces its price. Equilibrium multi-utility's profit then is

$$\Pi_U\left(\widehat{q},\theta,v\left(\widehat{q}\right)\right) = \frac{b\left[A+\widehat{q}\theta B - s^2(n-1)FE\left(\widehat{q},\theta\right)\right]^2}{4\left(2b+s\right)^2\left(2b-s(n-1)\right)^2}$$

where $A := 2(2b+s)(\gamma_U - c\left(b-(n-1)s\right)) > 0$ and $B := 2(2b^2-(n-1)s^2-(n-2)sb) > 0$.[29] In line with intuition, if the actual level of scope economies θ increases, multi-utility's profit increases and if rivals over-estimate scope economies (i.e. $FE\left(\widehat{q},\theta\right) \geq 0$), multi-utility's profit decreases.

It is also instructive to analyze the effects of cost announcement by the multi-utility. The cost-efficiency effect is as usual and induces the firm to understate scope economies. However, now due to strategic complementarity in market U, the multi-utility would like the rival react by increasing their prices and this can be obtained with (i) the direct-strategic effect by selecting a low production in the regulated market (i.e. $\underline{q}$ if the policy is such that $\overline{q} \geq \underline{q}$) and with (ii) the indirect-strategic effect by inducing the rivals believe that there are low economies of scope instead of high ones (i.e. inducing a negative forecasting error $FE \leq 0$). This shows how with strategic complementarity multi-utility's incentives to understate scope economies are aligned in the two markets so that the regulator will find it more difficult to obtain information revelation as compared with the case of strategic substitutability in market U.

Proposition 4 *The strategic (direct and beliefs related) effects of cost announcement make the information revelation process more difficult for the regulator: they induce larger informational rents for the multi-utility and may also imply uniform regulation.*

All this is even more relevant the larger is the number of rivals $(n-1)$ and the degree of product substitutability s.

We now investigate the desirability of bundling or unbundling of activities in the multi-utility. An immediate consequence of Proposition 4 is that the reasoning used for quantity competition is

[29] Note that $b-(n-1)s > 0$ implies $B > 0$.

no more viable. When firms compete on price, the regulator would prefer having informed and not uninformed rivals in market U, and if this is not the case then bundling multi-utility's activities involves a trade off. On one side, production efficiency increases with integration but on the other side informational rents and distortions in the regulated market also increase. Notwithstanding this trade-off, we obtain the following.

Proposition 5 *With price competing firms, bundling multi-utility's activities is desirable, even if the rival firms do not know the value of scope economies θ.*

This result follows from the observation that, from what stated above and contrary to quantity competition, with price competition the regulator would prefer having the unregulated market with asymmetric information. This can be accomplished in a very simple way. In fact, it suffices that the regulator employs optimal regulation $\mathcal{C}^S$ designed for unbundling because, by definition, this policy does not depend on θ. With this policy welfare in the regulated market is clearly unaffected by integration and the unregulated market become more competitive, thus increasing total welfare. It is also interesting to notice that the argument used to prove the result in Proposition 5 can be easily extended to the more general environment illustrated in Sections 2-5.

7 Concluding remarks

We have analyzed optimal regulation of a multi-utility firm that serves both a regulated and an unregulated market. When the multi-utility is allowed to bundle its activities scope economies arise which reduce the firm's costs. However, the extent of scope economies are not perfectly known by the regulator and the rival firms in the unregulated market. Thus, when the multi-utility is allowed to bundle its activities the regulator's tasks becomes more complex for the presence of (possibly additional) asymmetric information. Eliciting firm's private information, the regulator has to take into account how the unregulated market reacts to decisions in the regulated one also because this affects the multi-utility incentives in the regulated activity. We have thus discussed optimal regulation and its distortions due to asymmetric information when competition in the unregulated market takes place either on quantities or on prices (with differentiated products).

We then address the issue of desirability of letting the multi-utility to bundle and integrate its activities. With this respect a trade-off emerges. On one side, allowing the multi-utility to bundle activities reduces costs and if this is at least partially passed on lower prices, then consumers (possibly in both markets) may profit. On the other side, multi-utility's private information makes the regulator's task more difficult so that firm's private information entails distortions in the regulatory policy that negatively affect welfare. Notwithstanding, this trade-off we are able to show that if uncertainty introduced by bundling multi-utility's activities is uniquely on the dimension of scope economies, then bundling is socially desirable and if the multi-utility is allowed to do so it always prefer to take profit of this opportunity.

In this paper we have not explicitly considered the possibility that uncertainty introduced by bundling may also entail diseconomies of scope (which in our model would correspond to a case with $\theta < 0$). If this is a case, then the desirability of integration of multi-utility's activities is clearly weakened and the regulator should trade-off the positive effects of integration illustrated in our analysis with the risk of ending up with a less efficient multi-utility (as compared with the case where separation or unbundling is imposed).

Another set of potential benefits that we do not address in this paper relates to the demand side. Having captive customers in the regulated market allows the firm to capture those customers with the joint sale of the goods/services. This could be due to intrinsic advantages for customers of having only one provider for both services (joint billing, lower transaction costs summarized in the expression "one stop shop"). In addition, the possibility to tailor joint offers (bundling) at more advantageous conditions can also be a source of gains for consumers and of concerns on the part of competition. We leave this for future research.

In this paper we have discussed the informative role that a regulatory policy may have towards unregulated market. This informational externality from regulation towards the unregulated market has been addressed in a simple dichotomous way. Either the policy fully informs the rivals or it provides no information at all. This simple policy may not be optimal if the regulator could smooth-out the information provided to the unregulated market. Being regulated price naturally observable, a more sophisticated disclosure policy would require using stochastic regulatory contracts that may deliver only partial information. Even if our result on the desirability of a multi-utility will not be affected by this extension, it could be interesting to study optimal regulation associated with the optimal disclosure policy. Our analysis seems to point that when competition in the unregulated market takes place with strategic substitutability then some information disclosure should be optimal, while no disclosure may be preferable with strategic complementarity.

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8 Appendix

Proof of Proposition 1. *Step 1.* Substituting the profit of the regulated firm into the objective function (7) with $W^I(q,\theta,v) = W^I(q, y_1(q,\theta,v), y(q,v), \theta)$ program $(\mathcal{P}^I)$ becomes

$$\underset{\left\{\left(\overline{q},\overline{\Pi}^I\right),\left(\underline{q},\underline{\Pi}^I\right)\right\}}{Max} \quad E_\theta\left[W^I\left(q\left(\theta\right),\theta,v(q\left(\theta\right))\right) - (1-\alpha)\Pi^I\left(\theta\right)\right]$$

subject to constraints $IC(\theta)$ and $IR(\theta)$ for any θ which can be re-written as

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

Being $\Delta_\theta \Pi_U(q, v(q)) \geq 0$, constraints $IC(\overline{\theta})$ and $IR(\underline{\theta})$ imply that $IR(\overline{\theta})$ is slack and can be disregarded. Therefore, 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 limit where $IC(\overline{\theta})$ binds.

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

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

Note that if $\overline{q} = \underline{q}$, then $\Delta_\theta \Pi_U(\overline{q}, v) = \Delta_\theta \Pi_U\left(\underline{q}, v\right)$ and constraint $IC(\underline{\theta})$ is trivially satisfied.

Step 2. We can now rewrite program $(\mathcal{P})$ in the following equivalent way

$$(\mathcal{P}')\left\{\begin{array}{ll} \underset{(\overline{q},\underline{q})}{Max} E_\theta\left[W^I\left(q\left(\theta\right),\theta,v(q\left(\theta\right))\right)\right] - (1-\alpha)v\Delta_\theta\Pi_U\left(\underline{q},v(\underline{q})\right) - (1-\alpha)(1-v)\pi^S & \\ \text{s.t. } \Delta_\theta \Pi_U\left(\overline{q}, v(\overline{q})\right) \geq \Delta_\theta \Pi_U\left(\underline{q}, v(\underline{q})\right) & IC(\underline{\theta}) \end{array}\right.$$

Hence, let $\overline{q}^* \neq \underline{q}^*$ be solution of the following two first order conditions

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

where

$$\begin{aligned} SMC\left(q,\theta,v(q)\right) &= \frac{\partial W^I(q,y_1(q,\theta,v(q)),y(q,v(q)),\theta)}{\partial q} \\ &= \frac{\partial C}{\partial q} - \left[\left(p_U - \frac{\partial C}{\partial y_1}\right)\frac{\partial y_1}{\partial q} + (n-1)\left(p_U - \frac{\partial C}{\partial y}\right)\frac{\partial y}{\partial q} - (1-\alpha)(n-1)\frac{\partial \pi^I}{\partial q}\right] \end{aligned}$$

If $\Delta_\theta \Pi_U\left(\overline{q}^*,1\right) \geq \Delta_\theta \Pi_U\left(\underline{q}^*,0\right)$, then $\overline{q}^*, \underline{q}^*$ are the optimal regulated quantities, because they satisfy the unique constraint $IC(\underline{\theta})$ in $(\mathcal{P}')$. If instead $\Delta_\theta \Pi_U\left(\overline{q}^*,1\right) < \Delta_\theta \Pi_U\left(\underline{q}^*,0\right)$, solutions $\overline{q}^*, \underline{q}^*$ would violate $IC(\underline{\theta})$ so that the optimal solution requires pooling. In this case, whatever its type θ, the multi-utility firm is required to produce $\widetilde{q}$ that solves the following program (constraint $IC(\underline{\theta})$ is omitted because trivially satisfied when $\overline{q} = \underline{q} = \widetilde{q}$),

$$\underset{\widetilde{q}}{Max} E_\theta\left[W^I\left(\widetilde{q},\theta,v\right)\right] - (1-\alpha)v\Delta_\theta \Pi_U\left(\widetilde{q},v\right) - (1-\alpha)(1-v)\pi^S$$

where v is the prior belief $\Pr(\overline{\theta})$ on $\overline{\theta}$. ■

Proof of Corollary 1. The profit immediately follows from the fact that at the optimum constraints $IC(\overline{\theta})$ and $IR(\underline{\theta})$ bind, as discussed in the proof of Proposition 1.

We now discuss the sign of the distortionary term $\frac{\partial \Delta_\theta \Pi_U(q,v(q))}{\partial q}$ in both separating and pooling regulatory contracts, i.e. $\frac{\partial \Delta_\theta \Pi_U(q,0)}{\partial q}$ and $\frac{\partial \Delta_\theta \Pi_U(q,v)}{\partial q}$. We need to study how $\Delta_\theta \Pi_U\left(q,v\right)$ varies with q, keeping constant the rivals' beliefs on θ at v (the analysis for $v=0$ is similar). Recall that $\Delta_\theta \Pi_U\left(q,v\right)$ is the difference between unregulated profits for a type $\overline{\theta}$ and a type $\underline{\theta}$, $\Pi_U\left(q,\overline{\theta},v\right) - \Pi_U\left(q,\underline{\theta},v\right)$, generated by a regulated output q, unregulated market equilibrium $y_1\left(\overline{q},\overline{\theta},v\right)$ and $y\left(\overline{q},v\right)$ and for a given belief v hold by competitors. We then have

$$\begin{aligned} \frac{\partial \Delta_\theta \Pi_U(q,v)}{\partial q} &= \frac{\partial \Pi_U\left(q,\overline{\theta},v\right)}{\partial q} - \frac{\partial \Pi_U(q,\underline{\theta},v)}{\partial q} \\ &= \frac{\partial \Pi_U\left(q,\overline{\theta},v\right)}{\partial y_1}\frac{\partial y_1}{\partial q} + \frac{\partial \Pi_U\left(q,\overline{\theta},v\right)}{\partial y}\frac{\partial y}{\partial q} + \frac{\partial \Pi_U\left(q,\overline{\theta},v\right)}{\partial q} - \frac{\partial \Pi_U(q,\underline{\theta},v)}{\partial y_1}\frac{\partial y_1}{\partial q} - \frac{\partial \Pi_U(q,\underline{\theta},v)}{\partial y}\frac{\partial y}{\partial q} - \frac{\partial \Pi_U(q,\underline{\theta},v)}{\partial q} \\ &= \left[\frac{\partial \Pi_U\left(q,\overline{\theta},v\right)}{\partial y} - \frac{\partial \Pi_U(q,\underline{\theta},v)}{\partial y}\right]\frac{\partial y(q,v)}{\partial q} - \left[\frac{\partial C\left[q,y_1\left(q,\overline{\theta},v\right);\overline{\theta}\right]}{\partial q} - \frac{\partial C[q,y_1(q,\underline{\theta},v);\underline{\theta}]}{\partial q}\right] \end{aligned}$$

where we used $\frac{\partial \Pi_U(q,\theta,v)}{\partial y_1} = 0$. Recall that $y_1\left(q,\overline{\theta},v\right) \geq y_1\left(q,\underline{\theta},v\right)$, so that scope economies imply that the second square bracket is negative. This is the standard effect of asymmetric information on regulatory distortion that in standard models implies a downward distortion so that $\underline{q}^* \leq \underline{q}^I_{FI}$. However, the first square bracket is proportional to

$$\begin{aligned} &y_1\left(q,\overline{\theta},v\right)\ p'_U\left[y_1\left(q,\overline{\theta},v\right) + (n-1)y\left(q,v\right)\right] - y_1\left(q,\underline{\theta},v\right)\ p'_U\left[y_1\left(q,\underline{\theta},v\right) + (n-1)y\left(q,v\right)\right] = \\ &-\left\{p_U\left[y_1\left(q,\overline{\theta},v\right) + (n-1)y\left(q,v\right)\right] - p_U\left[y_1\left(q,\underline{\theta},v\right) + (n-1)y\left(q,v\right)\right]\right\} + \\ &-\left\{\frac{\partial C\left[q,y_1\left(q,\overline{\theta},v\right);\overline{\theta}\right]}{\partial y_1} - \frac{\partial C[q,y_1(q,\underline{\theta},v);\underline{\theta}]}{\partial y_1}\right\} \end{aligned}$$

which can be negative or positive. Hence, have that also $\frac{\partial \Delta_\theta \Pi_U(q,v)}{\partial q}$ may be positive or negative.

This implies that we can have $\underline{q}^* \geq \underline{q}^I_{FI}$. Furthermore, if the negative part in $\frac{\partial \Delta_\theta \Pi_U(q,v)}{\partial q}$ is sufficiently strong it can also happen that $\underline{q}^* \geq \overline{q}^*$. ■

Proof of Proposition 2. Assume that discriminatory regulation is optimal so that the optimal regulated quantities are $\overline{q} \neq \underline{q}$ (we will then check that this is indeed the case). Substituting $y_1(\widehat{q}, \theta, v(\widehat{q}))$ and $y(\widehat{q}, v(\widehat{q}))$ we have

$$\Delta_\theta \Pi_U(\overline{q}, 1) = \frac{\left[2(\gamma_U - c) + 2n\overline{q}\underline{\theta} + (n-1)FE(\overline{q}, \underline{\theta})\right]^2 - \left[2(\gamma_U - c) + 2n\overline{q}\overline{\theta}\right]^2}{4(1+n)^2} = \frac{\overline{q}\left(\overline{\theta} - \underline{\theta}\right)\left(4(\gamma_U - c) + \overline{q}k\right)}{4(1+n)}$$

and, similarly,

$$\Delta_\theta \Pi_U(\underline{q}, 0) = \frac{\left[2(\gamma_U - c) + 2n\underline{q}\overline{\theta} + (n-1)FE(\underline{q}, \overline{\theta})\right]^2 - \left[2(\gamma_U - c) + 2n\underline{q}\underline{\theta}\right]^2}{4(1+n)^2} = \frac{\underline{q}\left(\overline{\theta} - \underline{\theta}\right)\left(4(\gamma_U - c) + \underline{q}a\right)}{4(1+n)}$$

where $a \equiv \left(3n\overline{\theta} - \left(\overline{\theta} - \underline{\theta}\right) + n\underline{\theta}\right)$, $k \equiv \left(3n\underline{\theta} + \overline{\theta} - \underline{\theta} + n\overline{\theta}\right)$ and $a \geq k \geq 0$.

From the proof of Corollary (1)

$$\frac{\partial \Delta_\theta \Pi_U(\underline{q}, v)}{\partial \underline{q}} = \left[\frac{\partial \Pi_U(q, \overline{\theta}, v)}{\partial y} - \frac{\partial \Pi_U(q, \underline{\theta}, v)}{\partial y}\right]\frac{\partial y(q, v)}{\partial q} - \left[\frac{\partial C[q, y_1(q, \overline{\theta}, v); \overline{\theta}]}{\partial q} - \frac{\partial C[q, y_1(q, \underline{\theta}, v); \underline{\theta}]}{\partial q}\right]$$

where in the calculable model of this section

$$\begin{aligned}
&\frac{\partial \Pi_U(\underline{q}, \overline{\theta}, 0)}{\partial y} - \frac{\partial \Pi_U(\underline{q}, \underline{\theta}, 0)}{\partial y} = y_1\left(\underline{q}, \underline{\theta}, 0\right) - y_1\left(\underline{q}, \overline{\theta}, 0\right) = \\
&\quad -\frac{(n-1)FE(\underline{q}, \overline{\theta})}{2(n+1)} - \frac{2n\underline{q}(\overline{\theta} - \underline{\theta})}{2(n+1)} = -\frac{\underline{q}}{2}\left(\overline{\theta} - \underline{\theta}\right) \leq 0 \\
&\frac{\partial y(\underline{q}, 0)}{\partial \underline{q}} = -\frac{\underline{\theta}}{n+1} \leq 0 \\
&\frac{\partial C[\underline{q}, y_1(\underline{q}, \overline{\theta}, 0); \overline{\theta}]}{\partial \underline{q}} - \frac{\partial C[\underline{q}, y_1(\underline{q}, \underline{\theta}, 0); \underline{\theta}]}{\partial \underline{q}} = -y_1\left(\underline{q}, \overline{\theta}, 0\right)\overline{\theta} + y_1\left(\underline{q}, \underline{\theta}, 0\right)\underline{\theta} = \\
&\quad \left[y_1\left(\underline{q}, \underline{\theta}, 0\right) - y_1\left(\underline{q}, \overline{\theta}, 0\right)\right]\underline{\theta} - \left(\overline{\theta} - \underline{\theta}\right)y_1\left(\underline{q}, \overline{\theta}, 0\right) = \\
&\quad -\left(\overline{\theta} - \underline{\theta}\right)\left[\underline{q}\underline{\theta} + y_1\left(\underline{q}, \overline{\theta}, 0\right)\right] \leq 0
\end{aligned}$$

These imply

$$\begin{aligned}
&\frac{\partial \Delta_\theta \Pi_U(\underline{q}, 0)}{\partial \underline{q}} = \left(\overline{\theta} - \underline{\theta}\right)\left\{\underline{q}\frac{\underline{\theta}}{n+1} + \underline{q}\underline{\theta} + y_1\left(\underline{q}, \overline{\theta}, 0\right)\right\} \\
&= \frac{\left(\overline{\theta} - \underline{\theta}\right)\left(2(\gamma_U - c) + \underline{q}\left(3n\underline{\theta} + \overline{\theta} - \underline{\theta} + n\overline{\theta}\right)\right)}{2(1+n)} \geq 0
\end{aligned}$$

so that, as long as $\overline{\theta} > \underline{\theta}$, the distortion $(1-\alpha)\frac{v}{1-v}\frac{\partial \Delta_\theta \Pi_U(\underline{q}, 0)}{\partial \underline{q}}$ in the pricing condition for $\theta = \underline{\theta}$ illustrated in Proposition 1 is strictly positive. Clearly, if $\overline{\theta} = \underline{\theta}$ then uninterestingly $\overline{q} = \underline{q}$.

Now, constraint $IC(\underline{\theta})$

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

is here equivalent to

$$\left(\overline{q} - \underline{q}\right)4(\gamma_U - c) + \overline{q}^2 a - \underline{q}^2 k \geq 0$$

which here is satisfied when $\overline{q} \geq \underline{q}$ because $a \geq k \geq 0$. (Note however that $IC(\underline{\theta})$ could be satisfied even if $\overline{q} < \underline{q}$.) This implies that quantities $\hat{q}(\theta)$ for $\theta \in \Theta$ in Proposition 1 are indeed optimal and optimal regulation is discriminatory.

Finally, simple comparative statics with respect to γ_U and n shows points (ii) and (iii) in the proposition. Note that the derivative of $\Delta_\theta \Pi_U \left(\underline{q}, 0\right)$ with respect to n is proportional to $-(\gamma_U - c - \underline{q}^* \underline{\theta})$. However, from (19) we have $y\left(\underline{q}, 0\right) = \frac{\gamma_U - c - \theta\widehat{q}}{n+1} \geq 0$ and then $\Delta_\theta \Pi_U \left(\underline{q}, 0\right)$ is decreasing in n. ■

Proof of Proposition 3. Let $\mathcal{C}'$ be the optimal regulatory contract that the regulator would set were the rivals (but not the regulator) informed about θ and let $\mathcal{I}'$ indicate this particular information set. On the contrary, let $\mathcal{C}^*$ the optimal regulatory contract with the information set $\mathcal{I}^*$ where neither the regulator nor the rivals know θ as in the model setup.

The proof is in three steps. Assuming that the optimal policy $\mathcal{C}'$ for information $\mathcal{I}'$ is individually rational and incentive compatible also when applied to information $\mathcal{I}^*$, step 1 shows the effect on rivals' and multi-utility's profits if the regulator employs $\mathcal{C}'$ with information $\mathcal{I}^*$ and step 2 the effects on welfare. Steps 3 concludes showing that indeed $\mathcal{C}'$ is individually rational and incentive compatible when information is $\mathcal{I}^*$.

Step 1. Assume $\mathcal{C}'$ is discriminatory, incentive compatible and individually rational with information $\mathcal{I}^*$. consider what could happen if the regulator used contract $\mathcal{C}'$ when information is $\mathcal{I}^*$. First, rivals in market R would respond exactly as if information where $\mathcal{C}'$. Concerning the multi-utility we have that if $\overline{\theta}$ selects the regulatory policy designed for $\theta = \underline{\theta}$ in contract $\mathcal{C}'$, with information $\mathcal{I}^*$ it induces an incorrect belief $v(\underline{q}) = 0$ of the rivals and obtains a profit

$$\pi^S + \Pi_U \left(\underline{q}, \overline{\theta}, v(\underline{q}) = 0\right) - \Pi_U \left(\underline{q}, \underline{\theta}, v(\underline{q}) = 0\right)$$

where $\Pi_U \left(\underline{q}, \overline{\theta}, 0\right)$ shows that the rivals react to $\underline{q}$ by expanding their production also because they believe that scope economies are $\underline{\theta}$ instead of $\overline{\theta}$. When instead information is $\mathcal{I}'$ so that the rivals know the value of θ, type $\overline{\theta}$ by mimicking type $\underline{\theta}$ obtains

$$\pi^S + \Pi_U \left(\underline{q}, \overline{\theta}, v(\underline{q}) = 1\right) - \Pi_U \left(\underline{q}, \underline{\theta}, v(\underline{q}) = 0\right)$$

which shows that, even if $\underline{q}$ is observed, the rivals know that scope economies are large and $v(\underline{q}) = 1$ in $\Pi_U \left(\underline{q}, \overline{\theta}, 1\right)$. The different rivals' reaction with information $\mathcal{I}^*$ and $\mathcal{I}'$ imply that

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

so that

$$\pi^S + \Pi_U \left(\underline{q}, \overline{\theta}, v(\underline{q}) = 0\right) - \Pi_U \left(\underline{q}, \underline{\theta}, v(\underline{q}) = 0\right) \leq \pi^S + \Pi_U \left(\underline{q}, \overline{\theta}, v(\underline{q}) = 1\right) - \Pi_U \left(\underline{q}, \underline{\theta}, v(\underline{q}) = 0\right)$$

and then, being $\mathcal{C}'$ incentive compatible for type $\overline{\theta}$ with information $\mathcal{I}'$, it is so a fortiori with information $\mathcal{I}^*$ thus implying that when information is $\mathcal{I}^*$ type $\overline{\theta}$ obtains a smaller rent as compared to information $\mathcal{I}'$ which is

$$\pi^S + \Pi_U \left(\underline{q}, \overline{\theta}, v(\underline{q}) = 1\right) - \Pi_U \left(\underline{q}, \underline{\theta}, v(\underline{q}) = 0\right).$$

Step 2. Let $EW^I(\mathcal{C},\mathcal{I}) = E_\theta \left[W^I(\mathcal{C},\theta)\,|\mathcal{I}\right]$ be the expected social welfare associated with a regulatory contract $\mathcal{C}$ and information set $\mathcal{I}$. For what stated in step 1, if the regulator uses $\mathcal{C}'$ with information $\mathcal{I}^*$, she obtains a welfare $EW^I(\mathcal{C}',\mathcal{I}^*)$ which differs from $EW^I(\mathcal{C}',\mathcal{I}')$ uniquely because with information $\mathcal{I}^*$ the multi-utility earns a rent which is smaller than what it earns with information set $\mathcal{I}'$. Hence, it follows

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

Recall that remark 2 shows

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

and we know that contract $\mathcal{C}'$ is potentially suboptimal with information $\mathcal{I}^*$ so that

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

We then obtain the following inequalities

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

showing that if $\mathcal{C}'$ is discriminatory, incentive compatible and individually rational with information $\mathcal{I}^*$, then allowing integration of activities is better than imposing unbundling.

Step 3. Following the same steps as in the proof for Proposition 2 but with $FE = 0$, it immediately follows that optimal regulation $\mathcal{C}'$ with information set $\mathcal{I}'$ is indeed discriminatory, i.e. $\overline{q}' > \underline{q}'$.

Concerning incentive compatibility and individual rationality of $\mathcal{C}'$ with information $\mathcal{I}^*$, step 1 has already shown that with contract $\mathcal{C}'$ and information $\mathcal{I}^*$ constraint $IC(\overline{\theta})$ is satisfied. Furthermore, if type $\theta \neq \theta'$ selects the regulatory policy designed for $\theta = \theta$ in contract $\mathcal{C}'$, then the rivals infer that scope economies are that of type θ and react exactly as when the information set is $\mathcal{I}^*$. This immediately implies that $IR(\theta)$ is satisfied also with information $\mathcal{I}^*$, for any θ. Finally, from the proof of Proposition 2 we know that with information $\mathcal{I}^*$, for any regulation with $\overline{q} \geq \underline{q}$ then $IC(\underline{\theta})$ is satisfied.

This concludes the proof. ■

Proof of Proposition 4. The Proposition is formally proven by noticing that the informational rent $\Delta_\theta \Pi_U\left(\underline{q},0\right)$ of type $\overline{\theta}$ here can be written as,

$$\Delta_\theta \Pi_U\left(\underline{q},0\right) = \frac{b\left[A+\underline{q}\overline{\theta}B - s^2(n-1)FE\left(\underline{q},\overline{\theta}\right)\right]^2 - b\left[A+\underline{q}\underline{\theta}B\right]^2}{4\left(2b+s\right)^2\left(2b-s(n-1)\right)^2}$$

which is decreasing in $FE\left(\underline{q},\overline{\theta}\right)$. Hence, a firm with high scope economies can increase its rent by announcing low scope economies $\underline{\theta}$ so as to induce $FE\left(\underline{q},\overline{\theta}\right) = -\underline{q}\left(\overline{\theta}-\underline{\theta}\right) < 0$. This is the consequence of the belief-related strategic effect. Furthermore, one cans how that $\frac{\partial \Delta_\theta \Pi_U\left(\underline{q},0\right)}{\partial(n-1)} \geq 0$ and $\frac{\partial \Delta_\theta \Pi_U\left(\underline{q},0\right)}{\partial s} \geq 0$.

The asymmetric information distortion $\frac{\partial \Delta_\theta \Pi_U\left(\underline{q},0\right)}{\partial q}$ in the pricing condition remains positive because $\frac{\partial \Delta_\theta \Pi_U\left(\underline{q},0\right)}{\partial q} = \frac{(B+1)\left(\overline{\theta}-\underline{\theta}\right)\left(A+\underline{q}\left(\left(\overline{\theta}-\underline{\theta}\right)+B\left(\overline{\theta}+\underline{\theta}\right)\right)\right)}{18} \geq 0$ thus showing that also the direct strategic effect of cost announcement is negative for the regulator. Also note that the pricing conditions still imply that $\hat{q}(\overline{\theta}) \geq \hat{q}(\underline{\theta})$.

Simple calculations also show that

$$\begin{aligned}
\Delta_\theta \Pi_U\left(\overline{q},1\right) &= \frac{b\overline{q}\left(\overline{\theta}-\underline{\theta}\right)\left[2A+\overline{q}\left(-(n-1)s^2\left(\overline{\theta}-\underline{\theta}\right)+B\left(\overline{\theta}+\underline{\theta}\right)\right)\right]}{4(2b+s)(2b-(n-1)s)} \\
\Delta_\theta \Pi_U\left(\underline{q},0\right) &= \frac{b\underline{q}\left(\overline{\theta}-\underline{\theta}\right)\left[2A+\underline{q}\left((n-1)s^2\left(\overline{\theta}-\underline{\theta}\right)+B\left(\overline{\theta}+\underline{\theta}\right)\right)\right]}{4(2b+s)(2b-(n-1)s)}
\end{aligned}$$

so that the necessary condition for separation $\Delta_\theta \Pi_U\left(\overline{q},1\right) \geq \Delta_\theta \Pi_U\left(\underline{q},0\right)$ (see Proposition 1) is satisfied if and only if

$$2A\left(\overline{q}-\underline{q}\right) + B\left(\overline{q}^2-\underline{q}^2\right)\left(\overline{\theta}+\underline{\theta}\right) \geq \left(\overline{q}^2+\underline{q}^2\right)(n-1)s^2\left(\overline{\theta}-\underline{\theta}\right) \qquad (23)$$

As it can be immediately seen, in this case of price competition monotonicity is not sufficient for separation and optimal regulation may indeed require pooling. ■

Proof of Proposition 5. Consider the optimal contract with separation $\mathcal{C}^S$. We now check the welfare $EW^I(\mathcal{C}^S, \mathcal{I}^*)$ that can be attained when the regulator uses contract $\mathcal{C}^S$ even if the multi-utility is allowed to bundle its activities.

Clearly, contract $\mathcal{C}^S$ does not depend on θ so that with information set $\mathcal{I}^*$ (i.e. uninformed rivals are), the rivals will not obtain any information from this contract and remain with their prior θ^e. In this case equilibrium price of the rivals can be written as

$$p^{FI} = \frac{\gamma_U + bc}{2b-(n-1)s} - \frac{bs}{(2b+s)\left(2b-(n-1)s\right)} q^S \theta^e$$

where the first term in the r.h.s. is their price when unbundling is imposed to the multi-utility. The rivals reduce their price when bundling is allowed and, given complementarity this implies that also the multi-utility's price p_1^{FI} in market U is lower with bundling and regulation $\mathcal{C}^S$ than with unbundling. Hence, all prices in the unregulated market are lower. Furthermore, the multi-utility now enjoys economies of scope and produces more in the unregulated market so that it operates with lower costs. All this guarantees that welfare level in the unregulated market (i.e. the sum of consumers' surplus and profits) is larger than with unbundling.

Clearly, in regulated R the consumers' surplus is the same as with separation, while the multi-utility operates with lower costs. Hence, also welfare in the regulated market is larger than with separation.

We can thus conclude that

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

Recalling that $\mathcal{C}^S$ is potentially suboptimal with information set $\mathcal{I}^*$ we finally conclude that

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

■