INVESTMENT INCENTIVES AND INDUSTRIAL ORGANIZATION OF A NETWORK LOCAL PUBLIC UTILITY

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Investment incentives and industrial organization of a network local public utility

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Abstract:

The paper explores the cost-benefit of the separation of the function of managing networks and plants activities from the function of providing the final service to users for a public utility organised as a local natural monopoly. The article analyses in particular the problem of investment incentives, given the different informational structures of the two considered organizational alternatives. It turns out that the integrated solution gives rise to more socially productive investments and to lower tariffs than the unintegrated one. However the former can be socially desirable provided it doesn't imply a too high public outlay and a too strong reduction in service quality.

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1. Introduction

The separation of networks and plants ownership, and of the consequent maintenance and managing activities, from the final service to users managing is often considered as a fundamental requirement for liberalizing the markets of public utilities. However this is true provided that some conditions are fulfilled. The first and clearest one is that such separation should be feasible from the technological point of view. The second one is that the down-stream segment of service provision should work as a competitive market among several competitors on "the last mile". Another condition is that both segments of the vertically organized industry, in particular the final service, should contribute to the total costs in a meaningful way: a brachycephal separation wouldn't be entirely justifiable, given the transaction and administration costs of separation itself.

Indeed, the vertical separation between a natural monopoly – the up-stream managing of the network – and a (potentially) competitive market – the down-stream providing of the final service – may have positive welfare consequences, especially if both segments are adequately regulated. The first one must be regulated in order to discipline the conditions of access to the network and the second one to control the fulfilment of the standards of the quality service and also the dynamics of tariffs, if these are not properly set by the market. Someone observes that the vertical separation is

still socially convenient if also the down-stream segment, the final service, is ran as a natural monopoly – like the case of Water Service in Italy (Servizio idrico integrato, SII) - provided that a concurrence for the market is working by a contracting-out procedure - a public franchise bidding - or, in a subordinate way, an auction for selecting the private partner in a mixed company. The separation of ownership of networks and plants could be justified in this case for getting more easily public funds for financing investments without weighing too much on the final tariff. According to the perspective designed by the approach of Business administration studies, creating a specific real estate company for managing the up-stream segment is in any case useful as it could allow a useful specialization in structured finance activities, like securitization and public project financing.

Indeed the Italian SII, reformed in 1994 by the so-called Galli Law, has registered in the last years a strong reduction of investments, following and stressing a negative tendency already working since the first half of '80: in period 1993-2002 the amount of investment has reduced by 37%, showing only a moderate increase in last years. The reduction has been stronger for public work aimed at building purification plants, while investments for building sewer plants have been slightly increasing (Comitato per la vigilanza sull'uso delle risorse idriche, 2005). The investments fall has consequently increase infrastructures depreciation, increase the network losses and worsen the levels of service, as the continuity of provision to users (Anwandter and Rubino 2006).

The lack of infrastructures depends on several elements, but the necessity to cover each year the rates of depreciation with tariffs revenues may be considered as the most relevant, limiting and delaying the investment plans. In many Italian Local Authorities (AATO) initial tariffs are able to cover at most the operative costs and therefore are not sufficient to create further cash flows for financing investments. Thus the costs of new infrastructures and plants must be covered with inflows of capital by shareholders or with bank and investors debts.

The link industrial organization vs. investment incentive has been treated directly by Regione Lombardia which, by L.R. 2003 n. 26, "Disciplina dei servizi locali di interesse economico generale", has explicitly established the vertical separation and in particular, as far as the regional SII is concerned (by R.R. 28.02.2005, n.4), has gone over the organizational structure provided by Galli Law, based on a single integrated firm for managing networks as well the final service. Indeed, the Lombard model provides to attribute to a regional real estate company the tasks to propose to AATO plans and projects and to realize them by building new networks and plants and by restructuring the existing ones with extraordinary maintenance investments. The remaining functions – the managing of the final service only - should be instead assigned to the local firms, organised as private or mixed companies.

However, the separation, as long as it seems to allow a greater specialization in investment activities, doesn't seem to guarantee at the same time the existence of adequate incentives to carry on these investments. Such incentives seem to depend instead on other elements: first, the availability of financial resources and secondly the intent of the public body in charge to actually devote them at this aim. Getting a nice and roomy moneybox doesn't imply it will be ever filled up! Moreover, the separation implies a *double marginalization* – i.e. the insert among the costs of the firm managing the final service of the mark-up over the rent the real estate company wants to get - which, besides falling over the final tariff, has effects on investment incentives too. Therefore the crucial problem to guarantee adequate investment flows seems mostly to consist in finding feasible financial mechanisms which can well integrate the tariff, but this integration could be done directly to the firm unifying both tasks without performing any separation. The evaluation of this institutional alternative appears so important to require a theoretical exploration in order to get some operative hints.

This paper enter the not so wide set of theoretical analyses on vertical separation of a public utility industry in two monopolistic segments[1], by concentrating on the search of the most appropriate organization for increasing investment flows. The theoretical contributions analysing the relationship between industrial organization of a public utility and investment incentives are inserted in the stream originated by the theory of firm by Grossman-Hart-Moore[2]. This theory, based on incomplete contracts and property rights, has been applied in the seminal article on the cost-benefit of privatization of public utilities by Hart, Shleifer and Vishny (1997)[3] and, more recently, in the article by Hart (2003) on the cost-benefit of putting up *Private Public Parternship* forms for building public infrastructures. These analyses are oriented on studying the incentives to carry on two types of investments: those able to increase the quality of the service provided to users and those able to contain production costs. Therefore, we want to explore the alternative between vertical integration and vertical separation taking specifically into account the choice of the amount of investments. For defining our proper theoretical context it is useful to remind that, according to industrial organization theory, "integration is a matter of unification of control rights" (Gibbons 2005) and in this sense we are discussing the exposed problem.

Synthetically, we find that the vertically integrated firm always carries on more socially productive investments, i.e. containing costs as well increasing service quality. This univocal result

[1] Most of contributions on *unbundling* are concentrated on cases where the down-stream segment is competitive (Armstrong, Cowan and Vickers 1995, Laffont and Tirole 1996, Motta 2004). See Petretto (2005) for a contribution specifically concerning the effects of *double marginalization* in the case of two vertically linked monopolies.
[2] See Gibbons (2005) for a clear survey and an exact insert of G-H-M theory within the wider theory of firm and Bolton and Dewatripont (2005, ch.IV) per an excellent formal analysis.
[3] Within this stream of literature see also Besley and Ghatak (2001)

is meaningful because may be considered as a specific example of the more general statement due the property-rights theory of firm according to which "with ownership merging we get more investment" (Bolton and Dewatripont, 2005, p. 515). Indeed, this result, which contrasts with B&A view insisting in the opposite direction, is due, on one hand, to the greater ability in regulatory activities shown by a specific local Authority with respect to a generic public bureaucrat and, on the other, to the fact that the single integrated firm, organising network maintenance, providing access input and providing the final service, internalizes the investment effects on the operative costs and then on the final price. The integrated firm also invests more in activities of only costs containment if, in the unintegrated alternative, the information asymmetry between the public body and the Regulator is not too large and the share of public ownership of the down-stream firm engaged in the final service is high. In these circumstances, also the final tariff is lower because the unitary operative costs are lower and because there is no *double marginalization*. Lastly, again when both types of investments are greater with the vertical integrated firm and the share of public ownership of the final firm is high, the financial outlay of the public body – i.e. the transfers to firms - is higher with vertical integration.

In conclusion, we may say that the integrated solution could be socially more convenient if it wouldn't determine, given an excessive effort in containing operative costs, a too strong reduction of service quality and an excessive public outlay for subsidizing the firm. A pervasive and effective regulation, by controlling the fulfilment of the quality standards of the firm providing the final service, may resolve the institutional choice in favour of the integration case. Of course, a situation of a public body not particularly stressed by budget issues could move in the same direction.

The plan of the work is the following. In the next section we'll expose a stylized and simplified model which is however able of enlightening the essential elements of the considered institutional issue with reference to a generic network public service. It is a model obtained by re-elaborating that one by Hart (2003) with the insert of some elements of traditional basic model of regulation by Laffont and Tirole (1993)[4]. Section 3 is addressed to analyse the case of two vertically separate firms, one managing the network and the providing input access and one managing the finale service to users. Section 4 analyses instead the case of a single vertically integrated firm. Section 5 compares the performances of the two organizational solutions. The final section 6 contains some summarizing remarks.

2. The model

[4] The model has been recently re-proposed, enriched also with many interesting institutional clarifications, in Laffont (2005). Indeed, this book gives an exact idea of the leak for the economic science of Jan Jacque Laffont loss of two years ago.

The aim is to model, as said, two concrete alternative ways of organising a network local public utility:

(1) a public owned enterprise, owning directly the network and the plants, which realizes maintenance and equipment replacement investments and, then, contracts out only the final service to users to a private or mixed enterprise;

(2) a private or mixed owned enterprise which, after having received by a concession the infrastructures by a public body (thereafter the Public administration), is engaged in managing the final service to users; such vertically integrated firm realizes also the investments for the maintenance of the network and plants.

2.1. *Timing and information structure*

In the model we are going to build for comparing these two options we imagine three periods of time (for simplicity we neglect any discount process): at stage 0, networks, plants and other infrastructures become available for the service managing firms; a stage 1, the same equipment is replaced with maintenance and requalification investments; at stage 2 the final service, according to the chosen institutional form, is organised and provided to users.

In modality (1) a long term contract relationship arises between the Public administration and the in-house real estate company to which the plants and infrastructures are assigned with the task to maintain them. A second contract, the so called Contract service, is signed between the Public administration and the private or mixed company with the purpose of disciplining the provision of the final service, with a tariffs structure defined and controlled by a Regulator. In modality (2) a single contractual relationship (an entrusting convention) is settled between the Public administration and the entrusted enterprise which specifies also the structure of the investments the firm must to carry out. The Regulator, in this second case, is responsible of controlling both the dynamics of tariffs structure and the investments plan implementation.

In order to study the economic problem of choosing between the two organizational alternatives, we assume the following information structure as far as the variables referring to users benefits, investment costs and operative costs are concerned. The Public administration is able to observe only partially users benefits as it is in some sense distorted by aims not precisely linked to users welfare[5]. The Regulator is instead more concentrated, given its specific mission, to users protection and it has got a larger informational set about the social benefits of the service. The activity of regulation, especially if organised along the territory, can more carefully refer to the closeness of

[5] On several explanations of this hypothesis see Laffont (1999) e Dixit (1997, 2002). Most of the basic ideas are linked to the *multi-task – multi-principal* decision structure of public bodies and to some collusive behaviours of public bureaucracy.

users and their representative agencies[6]. Moreover, the Public administration is not able to observe either operative nor investment costs variables; therefore it relies on to the real estate company and to the Regulator, in case (1), and only to the latter, in case (2). The real estate company can observe only the variables describing, on one hand, the investment costs and, on the other, the production costs of access to the networks and infrastructures. The Regulator observes, instead, only the costs borne by the entrusted firm, the operative costs in the first case and the operative and investment costs in the second one. Therefore, the efficiency of the entrusted firm is conditioned by regulation activity effectiveness, while the efficiency of the up-stream real estate company is conditioned by the index of benevolence of the Public administration and of the management directly put in charge by this. In the theory of Political economy the degree of benevolence of the policy maker is defined in terms of discrepancy between its pay-off function and the social welfare function. In our case this, as we'll see, depends on the observability of the variables defining the users benefits and on the importance the Public administration assigns to the revenues coming from the enterprises on which it has some stake.

As far as the choice of tariff structure is concerned, we are following a model à la Laffont-Tirole (L-T), with complete information by the Regulator[7], according to which final tariffs are proportional to unitary operative costs. In modality (1), the real estate enterprise managing the plants does not cover with the revenues by access sale the investment costs and thus it is subsidised directly by the public owner, while the firm providing the final service to users, getting generally a profit, shares the dividends among the private and/or public owners. In modality (2), the integrated firm generally makes a loss, as it does not recover with the revenues from tariffs the operative costs plus the investment costs, and thus turns to a integrative financing intervention by the Public administration, in some sense organised by the Regulator. In this second case, it is then indifferent to know how the ownership shares actually are divided.

2.2. *The meaningful variables*

We set the benefit (surplus) to users as

$$U(y,i,e) = u(y)+\beta(i)-\gamma(e);\ u'>0,\ \beta'>0;\ \gamma'>0,\ u''<0,\ \beta''<0,\ \gamma''>0 \qquad (1)$$

and the structure of operative costs for managing the service, observable only by the Regulator, as

[6] These elements are deeply examined by Laffont (2005).

[7] In our case assuming information asymmetry by the Regulator with respect to firm technology (costs) and to manager *cost-containment* effort only complicates the analysis without adding further meaningful elements. Indeed, with the usual L-T hypothesis of cost function dichotomy, by which the effects on costs by adverse selection and moral hazard variables are separated from those by output, information asymmetry wouldn't modify the price and investment conditions, but would influence only the level of the public subsidy for guaranteeing the informational rent to boost the *high-cost* firm to send truthful messages. By referring to contracts theory we are assuming that a (partially) incomplete

$C(y,i,e) = [c(i,e)+a]y$; $c_i < 0$, $c_{ii} < 0$; $c_e < 0$, $c_{ee} < 0$ (2)

y represents the output level and consumption by users, thus $u(y)$ measures the correspondent direct benefit; i and e are investment costs. As in Hart (2003), i is a *cost-containing* and *quality –rising* investment as it is able both to reduce operative costs and to increase final service quality by means innovations with improve the functioning of networks and plants. e is instead a *cost-containing* but *quality –reducing* investment, i.e. able to reduce production costs but to the detriment of service quality. It could be a purely re-organization innovation, aimed, for instance, at reducing the employees for providing the final service and increasing their productivity. $c(i,e)$ is the unitary production cost and a is the unitary cost of access to networks and plants. For simplicity we assume that one unit of access is equal to one unit of output, y, so $[c(i,e)+a]$ represents the marginal (operative) cost of service managing. c_i and c_e are the marginal reductions of operative costs per unit of service output due to the two typologies of investment. $\beta(i)$ measures the effect of the first investment type on improving service quality and $-\gamma(e)$ measures the negative impact of the second one.

Before examining the two exposed cases of industrial organization let us consider the complete contracts (First best) situation, with all variables observable by Public administration and verifiable outside; therefore the former needn't any mediation neither by a network and plants real estate company or a Regulator.

2.3. *The full information benchmark (First Best) solution*

In this case we have to carry on a welfare maximization by directly choosing the contractible variables, y, i and e:

$$\underset{(y,i,e)}{\text{Max}}\ W = U(y,i,e) - C(y,i,e) - i - e \quad (3)$$

The first order conditions (F.O.C.) of (3) imply:

$$y=y^* \Rightarrow u'(y^*)=c(i,e)+a=p^* \quad (4)$$

$$i=i^* \Rightarrow \beta'(i^*)-c_i y=1 \quad (5)$$

$$e=e^* \Rightarrow -\gamma'(e^*)-c_e y \leq 1,\ =1 \text{ if } e>0. \quad (6)$$

According to condition (4), the optimal supply level to users is such that the marginal cost, of production and access, is equal to the marginal benefit; p^* is the correspondent optimal price, decreasing with both i and e. According to condition (5), the cost of 1 euro of investment i equalizes the marginal benefit to users, $\beta'(i^*)$, plus that one to the firm, $-c_i y$; while, according to condition (6), the marginal cost of investment e is greater than 1 euro, given that it incorporates also the effect of

contract has been signed between Public administration and network managing firm, while the Regulator is able to sign complete contracts with the regulated firms.

quality reduction, $\gamma'(e^*)$, and it is not lower than the benefit to the firm, $-c_e y$. However, while at the optimum it is $i^*>0$, as far as e, given that $-c_e(0)y \leq 1+\gamma'(0)$ as it is assumed to be socially unproductive, the corner solution is optimal: $e^*=0$. Therefore, in First best only *cost-containing* and *quality –rising* investments are carried on and the output level follows the traditional *MC pricing rule*. Implicitly the operative costs are financed by the tariff and the investment expenditures by a lump sum tax*:* $T^* = i^*$. When this financing means is not available, we have to explore more concrete Second best solutions, taking in due account the corresponding distortions.

3. Vertical unintegrated organization with two separated firms for running network and final service activities

Let us analyse the hypothesis of a firm A, entirely owned by the Public administration (P), which carries out the ordinary and extraordinary maintenance investments and contracts-out, possibly by auction, the final service to another firm B, owned by private shareholders or mixed, i.e. with a meaningful share owned by P itself. In any case, firm B is regulated as far as the tariffs dynamics is concerned[8].

The situation may be modelled with a sequential game where firm A plays the first move by deciding on investments i and e and by fixing the access price – or a rent for hiring the plants - p_a; then, firm B, by observing i, e and p_a, and taking into account the regulatory constraints, decides on the final tariff level p. The solution of the game is found, as usual, by backward induction: first, we are going to determine the tariff structure chosen by firm B, which depends on the rule of the price fixed by the Regulator R, on investments level and on the access price; second, we are going to determine the level of these variables, as strategies chosen by firm A.

3.1. *Tariff structure*

The tariff p, chosen by B taking into account the regulation rule, is given by the maximisation of the following utilitarian social welfare function:

$$\underset{(p)}{\text{Max}}\ \varphi(p) + \beta(i) - \gamma(e) + (1+\lambda)\alpha T_B + (1-\alpha)T_B \qquad (7)$$

where $\varphi(p)= u(y)-py$ is the net surplus, function of price (with $\varphi'(p)= -y$), α is the share of public ownership of the firm providing the final service, and $\lambda>0$ measures the worth for P of a unit of residual $T_B = [p-c(i,e) - p_a]\, y$. In other words, λ reflects the marginal cost of public funds (*MCPF*)

[8] Recall that in L-T context the Regulator activities are synthesized by imposing to the regulated firm an objective function as close as possible to social welfare function, taking account of the informational asymmetry and the second best framework (no lump sum taxes).

given to the distortion due to tax revenue[9] eventually needed to subsidise the firm, or, as it will be soon clearer, λ, weighted with α, reflects the relief to P budget from B dividends. Therefore, 1 euro of profit of B is worth (1+λ)α euro for P and (1-α) euro for B private owners. The budget needs of P are taken into account also by R which receives a specific mandate in this direction within the set of its missions.

From the F.O.C. of (7), with p_a, i, e as given, we obtain, through a *modified -Ramsey-condition,* the following *Lerner index* of B:

$$L_s^B \equiv \frac{p^B - [c(i,e) + p_a]}{p^B} = \frac{\alpha\lambda}{1+\alpha\lambda}\frac{1}{\varepsilon_s} \equiv \sigma_B \tag{8}$$

where $\varepsilon_s > 0$ is the elasticity of demand of the service which we suppose to be constant; thus also $\sigma_B \geq 0$ is constant, and for regularity requirements <1. Notice as this tariff structure can be decentralised throughout a *price-Cap* system with parameters appropriately chosen by R[10]. If $\lambda \Rightarrow \infty$, R receives a very strong mandate to take care of the revenues from the service activity, and then fixes a purely monopolistic price structure: $L_s^B = \frac{1}{\varepsilon_s}$. While, with α=0, it is $\sigma_B = 0$: the vertical unintegrated firm is totally private and R, given that it there is no room for acquiring revenues from firm B dividends, imposes the break-even point solution, such that $T_B=0$, i.e. $p^B = c(i,e) - p_a$. Notice that this condition derives also when B works as an oligopolistic firm in Bertrand equilbrium.

By transforming condition (8) in terms of regulated price, we obtain:

$$p^B = \frac{c(i,e) + p_a}{1-\sigma_B} \equiv [c(i,e) + p_a](1+\rho_B) \tag{9}$$

where $\rho_B=[1/(1-\sigma_B)-1]$ is the mark-up applied by firm B, which is = 0 if B is, as said, obliged by R o by competition to apply a tariff equal to its marginal cost. In general, instead, ρ_B decreases with the final demand elasticity ε_s and increases with α, as well λ.

Condition (9) defines the firm B reaction function to firm A strategies: $p^B = p(p_a, i, e)$, whose shape is given by the following partial derivatives:

$$\frac{\partial p}{\partial p_a} = \frac{1}{1-\sigma_B} > 0; \quad \frac{\partial p}{\partial i} = \frac{c_i}{1-\sigma_B} < 0; \frac{\partial p}{\partial e} = \frac{c_e}{1-\sigma_B} < 0 \tag{10}$$

3.2. *Access price and final tariff in equilibrium*

[9] For a recent comprehensive treatment of the notion see Gahvari (2006). Notice however that in L-T framework the MCPF is a constant parameter.

[10] The result is well known in literature and it may be found in the contributions on the theory of regulation of years '80 (Armstrong, Cowans and Vickers 1995); it has been also reused by Laffont (2005) in a similar context. In our case

Firm A now chooses the access price and the investment levels in this way:

$$\underset{(p_a,i,e)}{\text{Max}}\ \mu[\varphi\,(p(p_a,i,e)) + \beta(i) - \gamma\,(e)] + (1+\lambda)\,T_A \qquad (11)$$

In (11) μ, $1 \geq \mu \geq 0$, measures the ability of P – and then of the manager of A – of observing and taking into account the users benefits; ability which is, in general, lower than that one of R (for which it is, by (7), $\mu=1$). With reference to the theory of contracts (Bolton and Dewatripont 2005, chap. I), μ can be considered as a measure of the degree of contractual power acquired by users in surplus distribution; this power is assumed to be greater if it is a specific task of their informed sponsor, R, to oversee the fulfilment of the terms of the contract and then to govern the surplus maximization process. $\lambda > 0$ now measures how much it is worth for firm A one unit of the residual $T_A = [(p_a - a)\, y(p(p_a, i, e)) - i - e]$.

The optimal access price derives from the F.O.C of (11), after having considered (10)

$$-\frac{\mu y}{1-\sigma_B} + (1+\lambda)[y + \frac{(p_a - a)\, y'}{1-\sigma_B}] = 0 \qquad (12)$$

or from the following *Lerner index*:

$$L_a^A \equiv \frac{p_a - a}{p_a} = \frac{1-\sigma_B - \xi}{\varepsilon_a} \qquad (13)$$

where $\varepsilon_a > 0$ is the elasticity of demand of access input[11] and $\xi = \mu/(1+\lambda)$ is the index of the degree of benevolence of Public administration , i.e. the weight P wants or is able to put to users benefits in its objective function. This crucial index is going to depend positively on μ e negatively on λ; in particular $\xi \Rightarrow 0$, when $\mu \Rightarrow 0$ and/or $\lambda \Rightarrow \infty$.

In terms of access price, from (13), it results:

$$p_a = a(1+\rho_A), \qquad (14)$$

where

$$\rho_A = \frac{\varepsilon_a}{\varepsilon_a - (1-\sigma_B - \xi)} - 1 \qquad (15)$$

represents the firm A mark-up.

As it is $1-\sigma_B-\xi>0$, we have $\rho_A>0$ and $p_a>a$. With $\xi=0$, we have $L_a^A \equiv \frac{p_a - a}{p_a} = \frac{1-\sigma_B}{\varepsilon_a}$, which represents the totally non-benevolent access price structure. While, with $\alpha=0$, i.e. when B is totally

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{Max T_B s.t. $p \leq CAP$ (ψ)}, with $\psi = dT_B^*/dCAP > 0$, $\psi < y$, implies $L_s = [1-(\psi/y)]/\varepsilon_s = \sigma_{Cap}$ which, instead of σ_B, is not constant. The Regulator, in order to approximate condition (8), should choose CAP in a way that $\sigma_{CAP}=\sigma_B$.

[11] As we have assumed that one unit of access is equal to one unit of output, it is $\varepsilon_a = (p_a/p)\, \varepsilon_s$.

private, σ_B=0, and $L_a^A = \frac{1-\xi}{\varepsilon_a}$, which gives the highest access price A can apply, given the index benevolence of P.

By substituting (14) in (9) we get the equilibrium final price, corresponding to the organizational solution of vertical separation:

$$p^B = [c(i,e) + a(1+\rho_A](1+\rho_B) \tag{16}$$

where the role of the double marginalization in the two segments of the industry appears clear.

3.3. *Investment levels and financing*

i^A and e^A are the levels of investment decided by public firm A, and, once realised, observed by the firm managing the service, B, which works as a follower doing the second move. The optimum investment conditions derive from the F.O.C. of (11), by substituting (10):

$$-\frac{\mu c_i y}{1-\sigma_B} + \mu\beta'(i) + (1+\lambda)[\frac{(p_a - a)c_i y'}{1-\sigma_B} - 1] = 0 \tag{17}$$

$$-\frac{\mu c_e y}{1-\sigma_B} - \mu\gamma'(e) + (1+\lambda)[\frac{(p_a - a)c_e y'}{1-\sigma_B} - 1] = 0 \tag{18}$$

From (17) and (18), by substituting (13), we obtain the following two conditions:

$$\xi\beta'(i^A) - \vartheta c_i y = 1 \tag{19}$$

$$-\xi\gamma'(e^A) - \vartheta c_e y \le 1\,, =1 \text{ if } e^A>0. \tag{20}$$

where $\vartheta \equiv \frac{1-\sigma_B-\xi}{1-\sigma_B}$<1.

ξ and ϑ work as not independent shadow prices of social benefits (costs) associated to service quality and to operative costs containment. By comparing Second best conditions (19) and (20) with First best ones (5) and (6), it results i^A <i* and $e^A \ge e$*=0. Indeed, given that in general ξ<1 and then ϑ <1, in SB the marginal benefits of socially productive investments are undervalued when compared with the marginal cost; as far as socially unproductive investments are concerned, it is undervalued the marginal cost of quality reduction, as well the marginal benefit of per unit of output operative costs containment, so the chosen level is zero, as in FB, or it is positive and then in excess respect to the efficient one. Crucial is the role of the index of benevolence index, ξ: to the in-house firm A, not totally taking into account the users benefits while taking into account the budget needs, it is allowed an under-investment of i and probably a over-investment of e w.r.t. FB, still remaining in the contract. In particular, in the polar case of total non-benevolence, ξ=0, the two

conditions (19) and (20) become respectively $-c_i y=1$ and $-c_e y=1$, implying a more relevant under-investment of *i* and an over-investment of *e,* which is now strictly positive[12].

Lastly, the transfers to the two firms, A and B, are given respectively by:

$$T_A = \rho_A a y - i^A - e^A \quad (21)$$

$$T_B = \rho_B [c(i^A, e^A) + a(1+\rho_A)] y \quad (22)$$

$T_B>0$, as $\rho_B>0$, and firm B transfers to P a dividend equal to αT_B, which is higher the higher are the margins by A and B, and of course the share of public ownership, α. As for large projects like these ones the production access costs are reasonably lower than investment costs, it turns out, instead, $T_A<0$, i.e. a subsidy to A, totally borne by the public ownership.

4. Vertically integrated organization with a single firm managing both network and final service activities

Now we have a single enterprise, *C*, receiving in concession the infrastructures from P and carrying on both functions of running network and plants activities and providing the final service; so $C=A+B$. In this case C internalizes the effects of investments on the residual between the sale price to users and production costs. However the firm is regulated and thus chooses price and investment levels according to specified rules established by R, which is now involved not only on the definition of tariff structure but also in controlling the planned investments amount and their impact on service quality.

Firm C choose its strategies following a standard L-T maximization process:

$$\underset{(p,i,e)}{\text{Max}}\ \varphi(p) + \beta(i) - \gamma(e) + (1+\lambda) T_C \quad (23)$$

where $T_C = [p - c(i,e) - a] y - i - e$.

In case of large projects investments, T_C gives rise to a public subsidy for covering the difference between costs and revenues from tariffs; the subsidy is in some sense defined by R, but paid by P, independently on firm ownership allocation.

4.1. *The final tariff*

By elaborating the F.O.C of (23) we obtain a final price à la *Ramsey-Laffont-Tirole*:

$$L_s^C \equiv \frac{p^C - [c(i,e) + a]}{p^C} = \frac{\lambda}{1+\lambda} \frac{1}{\varepsilon_s} \equiv \sigma_C \quad (24)$$

Or, in terms of regulated price

[12] See Estache, Laffont and Zhang (2006) for a proof, although in a different and more general context, of the inverse relationship between network expansion and marginal cost of public funds, which in our case becomes direct with respect to the index of benevolence.

$$p^C = \frac{c(i,e)+a}{1-\sigma_C} = [c(i,e)+a](1+\rho_C), \quad (25)$$

which, also in this case, can be decentralised through a *price-Cap* system with parameters correctly chosen by R.

The final tariff incorporates the access cost without any mark-up given that this activity is internally managed by firm C, while implies a final mark-up - equal to $\rho_C=[(1/1-\sigma_C)-1]$ - increasing with λ. Notice, for future reference, that, if $\alpha<1$, it is $\sigma_C>\sigma_B$, being $\sigma_B = \frac{\alpha+\alpha\lambda}{1+\alpha\lambda}\sigma_C$ and then $\rho_C>\rho_B$, while, with $\alpha=1$, it is $\sigma_C=\sigma_B$ and $\rho_C=\rho_B$. Therefore, the single integrated firm applies a larger mark-up on unitary operative costs than the unintegrated firm only dedicated to supply the final service, provided the latter is not in-house.

4.2. *Investment levels and financing*

As far as the investment expenditures are concerned, firm C chooses i^C and e^C amounts in order to satisfy the following two conditions:

$$\zeta\beta'(i^C) - c_i y = 1 \quad (26)$$

$$-\zeta\gamma'(e^C) - c_e y \le 1, =1 \text{ if } e^C>0 \quad (27)$$

where $\zeta=1/(1+\lambda)$ is the index of benevolence of the integrated organizational structure, where the role of R is stronger and more pervasive.

Therefore, by comparing (26) and (27) with (5) and (6), it results, given that generally $\zeta<1$, $i^*>i^C>0$ and $e^C \ge e^*=0$. Thus, also the single vertically integrated firm makes an under-investment in the socially productive typology and also a probable over- investment in the socially unproductive one. Finally, the residual of C is given by:

$$T_C = \rho_C [c(i^C,e^C)+a]\, y^C - i^C - e^C \quad (28)$$

which is, as said, negative implying a subsidy from P.

5. The comparison of the two organizational systems

The cost-benefit analysis of the two alternative systems of providing the public service will be now carried on by separately examining the levels of investment, final tariff and public outlay. Indeed, an increase of socially productive investments implies a welfare improvement, while an opposite effect derives from an increase of the other typology of investments. Also a decrease of the final tariff, as well a reduction of the public subsidy, given the MCPF, are welfare improving. It is not always possible to univocally ascertain the sign of the total effect of the change from a

organizational structure to another, however, some special cases on the parameters can allow some useful and interesting insights.

5.1. *Cost-containing and quality-rising investments: i*

The single firm C carries always out a higher level of this type of investments than firm A, separated from B: i.e. $i^C > i^A$.

The result derives by combining (19) with (26) and taking into account that, in general, $\zeta > \xi$ and $\vartheta < 1$. Therefore, in case of a single integrated firm C, not only the index benevolence of P is higher, but also is higher the weight attached to the benefits of operative costs saving. In fact, these are internalised by the same firm carrying out the investments, while, in case of non integration, the gains remain external to A.

Thus we have a classical hold-up effect (Gibbons 2005 and Bolton and Dewatripont 2005, ch. IV) boosting the single integrated firm to a higher socially productive investments level, even at the same index of benevolence.

5.2. *Cost-containing and quality-reducing investments: e*

For this kind of investments the comparison gives rise instead to uncertain results. On one hand, from (20) and (27) we see that the higher index of benevolence in case of a single firm is boosting now to contain the expenditure *e,* given the higher weight attached to users marginal cost from quality reduction. On the other hand, the higher weight on costs savings tends to increase *e*. In general, the sum of these two effects gives an ambiguous outcome.

However, some special cases are interesting enough[13]:

- $\mu \Rightarrow 0$, i.e. P (and A) has a limited information on users benefits, so $\xi = 0$ and $\vartheta = 1$, while it is still $\zeta > 0$. Therefore, $e^A > e^C$.
- $\mu \Rightarrow 1$, i.e. P, is, like R, perfectly informed on users benefits. Thus, in both cases we have the same index of benevolence: $\zeta = \xi = 1/(1+\lambda)$. However, as it is always $\vartheta < 1$, the single firm C carries out more investments *e* than the upstream firm A: $e^C > e^A$.
- $\alpha \Rightarrow 0$, i.e. the potentially making profits firm B is totally private, but also perfectly regulated by R, or competitive; thus it doesn't transfer any dividend to P. In this case $\vartheta_{\alpha=0} = max\, \vartheta = 1 - \xi$; in other words, the shadow price of the benefit coming from operative costs saving due to *e* is the highest possible, given the analysed SB situation.

[13] Hereafter we assume that $e^k > 0$, $k = A, C$.

- $\alpha \Rightarrow 1$, i.e. B is a in-house firm which transfers all the profits to P; thus $\sigma_B=\sigma_C$ and $\vartheta_{\alpha=1} = min\,\vartheta = \frac{1-\sigma_C-\xi}{1-\sigma_C}$ and therefore the shadow price is now the lowest one.
- $\lambda \Rightarrow \infty$. We may refer to this as a financial stress situation for P, implying $\zeta=\xi=0$, $\vartheta=1$, and then $e^A=e^C$ (but also $i^A=i^C$).

To sum up on this point, we, firstly, have that it tends to be $e^C>e^A$ ($e^A>e^C$) if the distance between the two indexes of benevolence, decreases (increases). Indeed, the weight to the marginal cost of socially unproductive investments in terms of quality increases (decreases); therefore, these investments are becoming less and less (more and more) convenient than those directly made by the single firm C. Secondly, if the public share of ownership of B increases (decreases), even at the same index of benevolence, e^A is decreasing (increasing) relatively to e^C: one euro of the operative costs saved by B is worth less and less (more and more) than it is worth by C, i.e. 1.

This outcome should be explained as it could appear counterintuitive, in particular when B is a totally private firm. In this case, A applies a high access price (see (13)), thus, by knowing that the final tariff is forced to be equal to marginal (operative and access) cost, in order not to weigh too much on the final tariff (a worry which in any case depends on the index of benevolence) it invests in *e* for reducing B operative costs instead of access costs. However, if B is a in-house firm, all the profits are acquired by P, therefore A keeps low the access price and invests relatively less in *e*. Thirdly, as long as the financial needs of P increase, both socially productive and unproductive investment decisions tend to be uniform in the two cases.

5.3. *The final tariff: p*

Two elements push the down-stream firm B towards a higher tariff than that of the single firm C: the greater reduction of operative costs that, for the latter, comes from a higher *i* level and the double marginalization effect in case of vertical separation. Only one element, instead, could push in the opposite direction: the eventual stronger reduction of operative costs of B due to a higher level of investments *e*.

The outcome of the comparison is then conditioned by the two previous comparison about *i* an *e*. By comparing (16) and (25), with $\lambda < \infty$, we obtain a unique result if $e^C > e^A$ (recall that $i^C > i^A$ is always true). In fact, in this case, $c(i^C,e^C)< c(i^A,e^A)$; moreover, as $\rho_A>0$, it is $p^B>p^C$.

As previously specified this possibility is becoming more and more likely as the difference of the two indexes of benevolence decreases.

5.4. *Transfers from and to firms*: $T_A + \alpha T_B$ vs. T_C

As far as the budget outlay of Public administration P is concerned, it doesn't emerge a clear sign by the organizational structure change; it is only possible to show, according to specific values of the relevant parameters, some tendencies of economic relevance. For instance, we may say that P outlay tends to be greater in case of a single firm C if

(i) $e^C > e^A$

(ii) the elasticity of final service demand, ε_s is low (as this is the case for instance in Water service) and

(iii) the share of public ownership of B, α, is high.

Indeed, from (21), (22) and (28) we obtain that $T_A + \alpha T_B \geq T_C$, if

$$\rho_A a y^B - i^A - e^A + \alpha\rho_B[c(i^A, e^A) + a(1+\rho_A)]y^B \geq \rho_B[c(i^C, e^C) + a]y^C - i^C - e^C \qquad (29)$$

or

$$\rho_A a y^B + (i^C - i^A) + (e^C - e^A) \geq \rho_B[c(i^C, e^C) + a]y^C - \alpha\rho_B[c(i^A, e^A) + a(1+\rho_A)]y^B \qquad (30)$$

If $e^C > e^A$, as we have previously seen, it is $c(i^C, e^C) < c(i^A, e^A)$, $p^B > p^C$ and then $y^C > y^B$. Consequently, the sign of right hand side of (30) is influenced by two opposite effects; however it will be negative if the elasticity of final service demand is not too high (then $y^C \approx y^B$) and if α is high. The left hand side of (30) is, instead, at the same conditions, positive; thus, $T_A + \alpha T_B \geq T_C$.

5.5. *Trying a summing up*

The following Table 1 is summarizing the variations accountancy, according to some meaningful values of the main parameters.

Table 1: Cost-Benefit of the change from C to A and B

	Sign	ΔW
$\Delta\beta = \beta(i^A) - \beta(i^C)$	<0	-
$\Delta\gamma = \gamma(e^A) - \gamma(e^C)$	<0 if μ and α are high	+
$\Delta\varphi = \varphi(p^B) - \varphi(p^C)$	<0 if $e^C > e^A$	-
$\Delta T = T_A + \alpha T_B - T_C$	>0 if $e^C > e^A$, ε_s is low and α high	+

It is clear that from this matrix of effects a definite solution doesn't derive. The final outcome of the change from a vertically integrated structure, with a single firm C, to a vertically unintegrated one, with two firms: up-stream A and down-stream B, is indeterminate. With the imagined values of the parameters, two components push to a decrease and one to a increase of social welfare. However we may say that now the main arguments involving the organizational choice are clearly on the ground.

6. Some concluding remarks

In many industrialized countries it seems to be quite relevant the problem of an inadequate amount of investments, then of a wide lack of infrastructures, in local public utilities, specially if organised as natural monopolies. Surely this is the case for Italy as far as public services like Water supply and Garbage collection and disposal are concerned.

In this work we have presented a theoretical model linking investment incentives to the organizational structure for the supply of a network local public service. The aim has been to compare two possible organizational solutions: the one based on the vertical separation between networks and plants running activities and final service managing activities, the other based on the integration of both functions. In order to ascertain the sign of the welfare changes we have firstly emphasized that an increase of socially productive investments – those able to contain costs as well to increase quality – surely implies an improvement, while opposite is the effect of an increase of the other type of investments - those cost-reducing but to the detriment of the quality of the service.

Notice that in a First best, complete information, framework only the first type of investments must be carried out and in a higher amount than those carried on in both considered Second best solutions. Secondly a tariff reduction, on which level both types of investments act by reducing operative costs of final service segment, implies a welfare improvement. Finally, given the marginal cost of public funds, a decrease of budget exposure of Public administration is socially convenient. Consequently we reached the following results.

The vertically integrated firm carries out a higher level of socially productive investments because it internalises their effects on operative costs and given that, in this case, a well informed Regulator now extends its ray of action also to investments plans and to the respect of quality standards. However, the chosen level is a Second best one, i.e. lower than the efficient First best one. As far as the socially unproductive investments are concerned, we may say that they are higher in the vertically integrated firm if, in the unintegrated structure, the informational asymmetry between the Public administration and the Regulator - then the discrepancy between the indexes of

benevolence of the two situations - decreases and if the share of public ownership of the firm engaged in providing the final service is sufficiently high.

Therefore, at this level of generality it is not possible to affirm in which of the two organizational systems the quality and the correspondent users benefits are higher. However, the single firm acting both functions tends to apply lower final tariffs because it is boosted to contain costs by means of both types of investment and there is no double marginalization at all. The down-stream firm engaged only in the final service applies higher tariffs because it inserts among the costs the mark-up incorporated in the access price it must pay to the up-stream real estate company and moreover it has higher operative costs given a lower amount of both investment types carried on by the up-stream firm managing the network and the plants. On the contrary, in the case of vertical separation, a high mark-up applied by the up-stream firm and a high share of public ownership of down-stream firm boost towards an improvement of the financial budget of Public administration.

The main result however remains that, unlike what sustained by a typical business and administration approach, we have a higher amount of socially productive investments with the integrated structure of the industry and a single firm. Some contraindications may derive by a worsening of quality service, given the strategies of reducing operative costs and by a greater budget outlay of Public administration. However, a solution at least to the first inconvenient could be actually found in a specific and effective regulatory activity carried on by an independent Authority.

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