ECONOMIES OF VERTICAL AND HORIZONTAL INTEGRATION, UNBUNDLING AND QUALITY OF SERVICE IN PUBLIC UTILITIES. A LITERATURE REVIEW

Clementina Bruno

Working Paper n. 5/2011

© HERMES
Fondazione Collegio Carlo Alberto
Via Real Collegio, 30
10024 - Moncalieri (TO)
Tel: +39 011 6705000
+390321375414

info@hermesricerche.it

http://www.hermesricerche.it

ECONOMIES OF VERTICAL AND HORIZONTAL INTEGRATION, UNBUNDLING AND QUALITY OF SERVICE IN PUBLIC UTILITIES. A LITERATURE REVIEW

Clementina Bruno[1]
(University of Bergamo and HERMES)
clementina.bruno@libero.it

Working paper n. 5/2011

ABSTRACT**.** This work is aimed to present a review of the literature on economies of vertical and horizontal integration, focused on the public utilities industry. First of all, the definition of economies of scope and the different methods of evaluation are illustrated. Subsequently, the problem of integration connected with the implementation of unbundling (business separation) policies is presented for different categories of utilities (energy, telecommunications, water, multiutilities). The literature results quite rich concerning the electricity sector, where economies of horizontal and vertical integration seem to prevail. Paradoxically, it is the sector where the implementation of (vertical) separation policies aimed to foster competition has reached the most advanced level. Vertical unbundling is also broadly applied in the gas sector, where it seems to have been less costly in terms of loss of operational efficiency. In fact, the empirical evidence (here scarcer), does not show synergies coming from the joint management of upstream and downstream segments. About the water sector, the existing studies do not report unanimous results. However, the finding of no important synergies between water supply and sewerage seems to prevail. Instead, vertical economies seems to exist by managing jointly the different stages of the drinking water supply (water "production", treatment and distribution), at least for some levels of output. The telecom industry has recently been involved in a wide debate concerning the cost and the opportunities of vertically separating the incumbent firms (in fixed telecom). It is also the sector where empirical findings on integration are more heterogeneous. The existing works mainly rely on quite old dataset, which constitutes a relevant limit in an industry whose technology evolves rapidly. Finally, the multi-utilities sector is analyzed. Important economies of scope emerge from the joint production of several services (energy, gas and water supply). Such economies seem to be correlated to the firm dimension, and larger for small level of output, while they decrease or turn into diseconomies for large production levels. Finally, the problem of the quality of service is treated, by examining the indicators used in these different sectors, and it is linked to the problem of integration. At the present moment, empirical studies on economies of integration rarely involve quality measures, while the importance of such an element in terms of consumer welfare suggests that it can be an interesting point to be considered in future research.

[1] The author acknowledges a grant for the Lagrange Proejct – CRT Foundation.

INDICE

1. Introduction 5
2. Vertical and horizontal integration in public utilities. 5
3. Economies of scope: definition and evaluation. 7
4. Energy 8
5. Telecommunications 14
6. Water 17
7. Multiutilities 21
8. Quality of service 24
9. Conclusions 25

References 27

1. Introduction

During the last two decades, the public utilities industry has undergone major regulatory reforms in developed and developing countries, mainly concerned with the privatization and the liberalization of these sectors. As a consequence of such a process, the economics of public services has been involved in a relevant academic and non-academic debate, which highlighted, among other issues, those ones related with the degree of integration of the operating firms and the related problem of unbundling.

The main considerations in implementing unbundling (business separation) policies are related to the correct balance between potential gains in terms of improved competition and potential cost efficiency losses. The latter can occur due to the existence, in public utilities as in many other industries, of economies of scale and, more concerned with the integration issue, economies of scope.

Competition and firms cost efficiency are a concern for regulators since they affect prices consumers face, and therefore their welfare, which however is also influenced by the quality of the service they are supplied; therefore the latter is as well an issue for regulators.

This work will provide a review focused on the definition and the evaluation of economies of scope in general, and on the empirical evidence of their existence and magnitude in different public services. Far from being exhaustive, this survey is aimed to provide examples of which kinds of integration and which possibilities for separation are a concern for regulators in energy, telecom, water and multiutilities sectors, showing which are the (sometimes controversial) main findings in empirical research. Moreover, the quality of service issue will also be treated and connected with integration and unbundling problems.

The paper is organized as follows. The next section illustrates the meaning of vertical and horizontal integration and unbundling, with focus on the public utilities. Section 3 explains the definition and the methods of evaluation of economies of scope. Section 4, 5, 6 and 7 analyze the integration and unbundling issues for energy, telecom, water and multiutilities sectors, respectively. Section 8 introduces the problem of quality of service. Section 9 draws some conclusions.

2. Vertical and horizontal integration in public utilities.

Integrated firms are able to provide multiple outputs. As illustrated in Montgomery (1994), there are three main reasons for which firms can decide to diversify their production.

Following the *market power view*, the reason driving towards integration is the possibility to enjoy larger market power and to undertake anti-competitive behavior: cross subsidization (a firm uses profits coming from one market to sustain predatory prices in another one), mutual forbearance (firms “meeting” each other in several market are more likely to collude) and reciprocal buying (in order to foreclose the market to smaller competitors) are the main risk for competition.

The *resource view* (Penrose, 1959), suggests instead that firms diversify in order to reach a more efficient exploitation of excess capacity. This is especially relevant when one or some production factors are *quasi-public*, i.e. their service can be “shared by two or more product lines without complete congestion” (Panzar and Willig, 1981, p.270), and when such inputs cannot be traded in the market without significant transaction costs (therefore the firms prefers to keep them for internal use).

The *agency view*, finally, recognizes firm's integration as a consequence of the managerial tendency towards empire building. Managers could pursue the goal of a enlarging firms boundaries just to increase their personal power, or to consolidate their position, for instance increasing firm's demand for their personal skills or reducing firm's risk through the diversification of the business. Sometimes such strategies can be undertaken at shareholders expenses, as they are not driven by value-maximizing reasons.

The latter issue is mainly matter of internal corporate governance, as it involves the principal-agent relationship between shareholders and managers. The *market power* and *resource views,* instead, are a concern for regulators controlling public utilities activity for the above mentioned reasons. In fact, they are facing a relevant trade-off: integration should be limited in order to foster competition, which would benefit consumers through lower prices. However, such a limitation would not allow the exploitation of economies coming from integration, thus increasing firms' costs and probably affecting the final price for the consumers themselves. Therefore it is crucial for regulators to correctly identify the magnitude of potential benefits in term of competition coming from the implementation of unbundling (business separation), and the value of potential losses in term of economies of scope (economies of joint production) that cannot be exploited.

Economies of scope can derive from vertical or from horizontal integration.

A firm is *vertically integrated* when it operates at successive levels in the production chain (e.g. generation and distribution of electricity). Following Kaserman and Mayo (1991) and Garcia et al. (2007), cost saving coming from vertical integration (as an alternative to separated firms exchanging resources through the market mechanism) can arise for several reasons. First, when the upstream firm enjoys some monopolistic power in pricing the intermediate product, this may lead to an inefficient input combination in the downstream stage, if the downstream firms can substitute inputs. Second, vertical integration is a way to avoid transaction costs related to the market exchange. Moreover, Garcia et al. point out a third effect, related to technological economies coming from physical interdependencies in production (complementarities and coordination economies).

When a firm operates in different industries or in several branches of the same industry, but remaining at the same level of the production chain, then *integration* is *horizontal.* In public network services a relevant example is the presence of multiutilities, i.e. firms providing jointly bundle of outputs such as telecommunications, water, gas and electricity distribution. Once again, the reasons why relevant cost savings can emerge are several (Fraquelli et al. 2004): the use of similar assets (networks), whose maintenance requires similar skills, synergies in the management of customers, in advertising and in administrative activities, a stronger position in raising funds.

Such (potential) benefits would be lost if Governments or regulators decide to undertake policy choices leading to the unbundling (business separation) of public utilities. Unbundling is aimed to foster competition, in order to benefit consumers through lower prices. Until now, the public utilities industry has been mainly concerned with *vertical unbundling*. This is because, in general, not all the production stages are characterized by natural monopoly. What it is not economically convenient to replicate in such sectors is the network: in that stage the presence of (regulated) monopoly is justified. Upstream and downstream stages could instead be opened to competition, since there the technology allows for the presence of several operators. In order to avoid anticompetitive behavior by

the incumbent monopolist, in many cases the separation of the "natural monopoly" stage has been seen as a solution. *Horizontal unbundling* is mainly related to multiutilites, as a way to foster competition, with the additional advantage of increasing the comparability between firms when benchmarking is used as a regulatory tool (Farsi et al., 2008).
The degree of separation is a further issue that regulators must face. As illustrated in Cave (2006), the weaker form is accounting separation, which entails separate financial statements for the separated units. The strongest one is structural separation (the separated entities cannot belong to the same ownership). Between the two extreme options lies functional or operational unbundling, itself ranging from the creation of a separate division to legal separation (where legally separated entities are allowed to belong to the same ownership).
Summarizing, in the regulatory choice of whether or not to implement an unbundling policy, and to choose between a more or less pervasive one, it is very important to evaluate the potential benefits in term of competition and to compare them with the costs that can emerge from firm "disintegration", in terms of potential loss of economies of scale and, above all, economies of scope. To the method of evaluation of the latter is devoted the following section.

3. Economies of scope: definition and evaluation.

Following Baumol, Panzar and Willig (1982), economies of scope are said to exist if it is cheaper to produce a given set of outputs by means of a single diversified firm than through several specialized firms. In the two output case, the measure of economies of scope is given by:

$$SC = \frac{C(Y_1,0)+C(0,Y_2)-C(Y_1,Y_2)}{C(Y_1,Y_2)} \qquad (1)$$

If *SC* > 0, the integrated way of producing is cheaper than the specialized one, than economies of scope occur. Otherwise, if *SC* < 0, we have diseconomies of scope.
There are two main sources of (positive) economies of scope. One is related to the possibility of sharing some not specific fixed inputs among different production lines. The other one is related to cost complementarity that occurs when the production of one output reduces the marginal cost of producing another output.
From an empirical perspective, the most used method is to evaluate the magnitude of economies of scope through a cost function. After the function estimation, economies (or diseconomies) are computed as in equation (1) using the predicted value of cost for the output level or combination of interest (see, among the others, Fraquelli et al., 2004, for multiutilities; Stone and Webster, 2004, for water; Kwoka, 2002, for electricity, etc. These examples are provided just to remain within public utilities literature). The choice of the functional form is not a trivial matter: logarithmic forms such as the well-know translog function, are, in general, not suitable. In fact, as emerges from the equation above, to evaluate economies of scope it is necessary to deal with zero-level output and logarithmic function are not defined at zero. However, they allow computing the cost complementarity component. Broadly used cost functions are instead the quadratic and the composite.

Moreover, by estimating a cost function, it is possible to indirectly detect the existence of vertical economies testing the cost separability of the production stages. Such an approach has been as well largely employed in empirical investigations (see, for instance, Hayashi et al., 1997, for electricity).

By using (average) cost functions, an underlying assumption is that the firms in the sample are minimizing costs. Grosskopf et al. (1992) argue that it can be a too narrow assumption: a frontier technique, allowing for the presence of inefficiency, could be superior as can avoid confusion between inefficiency and true economies or diseconomies of scope. The authors, in the mentioned contribution, provide an example related to agricultural production by using a parametric method, i.e. they estimate a (frontier) cost function. However, frontier techniques include also non parametric methods, that have been shown to be suitable for the estimation of economies of integration. These methods, such as Data Envelopment Analisys (DEA) (see for instance Arocena, 2008, for a contribution on electricity; Growitsch and Wetzel, 2007, which apply a similar methodology for railways; Bogetoft and Wang, 2005, for the theoretical presentation and a practical application of a particular method to compute size and mix economies; Fortin and Leclerc, 2006, for an output oriented framework and an application to the banking sector;) or Free Disposal Hull (FDH; Marques and De Witte, 2011, provide an example for the water sector) have the advantage to be flexible, as they do not impose any predetermined functional form, but present some drawbacks, such as the complicated statistical inference and the fact that they do not separate inefficiency from the noise component.

It is evident that many methods are available for the estimation of economies of scope. The following sections will provide some insights on the integration problem and on the empirical evidence about economies of scope in some important network industries.

4. Energy

This section will treat the separate supply of gas and electricity. Their joint provision will be analyzed in section 6.

Historically, energy utilities operating in gas and electricity sectors have been vertically integrated since their origin. It is likely to be due, at least in part, to the need of coordination among production stages that characterize their technology. This is especially evident for electricity: for its nature of non-storable good, it is necessary to have a constant balance between demand and production, and this goal is probably less hard to achieve under a vertically integrated structure. However, the recent regulatory tendency is to promote vertical unbundling of the transmission and distribution network. In fact, on the production side, the scale properties of the technology allow now for the presence of several competitors, while the same does not hold for the transmission and distribution stages, which still show relevant natural monopoly features. Therefore, the vertical break-up of the production chain has been used as a solution to avoid anti-competitive behavior of the incumbent firm, as highlighted in Fraquelli et al. (2005): *"In a regulated and partially liberalized market incumbents can in fact be left with substantial market power and distort competition in several ways. In the generation stage, they might limit the supply in order to keep prices high. In the transmission stage, they might charge discriminatory prices for the right to use the transmission grid. Cross-subsidization practices and predatory behavior are* *other dangers in the cases in which transmission, distribution and supply activities are run by the same company. Summarizing, vertical separation, far from being an end in itself, can be justified to the extent that the above market distortions outweigh the efficiency gains of vertical integration".*

Vertical unbundling between production (or imports) and distribution is going to be more and more accepted and implemented by regulators of most industrialized countries. The process has been more rapid for electricity, while it encountered more difficulties in the gas sector (Soares and Sarmento, 2009); the unbundling issue, in the latter, is related to the separation of transportation (natural monopoly) from the retail segment (potentially competitive). However, even if the process is far from being completed, there exist for both the energy branches many examples of unbundling, in some cases implemented in the more pervasive option of ownership separation. Even if this process will lead to important advantages in term of competition, the vertical integrated structure that dominated the market until the '90s suggests that important cost advantages may be lost by separating upstream and downstream stages. At least for the electricity industry, many contributions in the literature consider this issue.

As mentioned in the previous section, one way to (indirectly) check the existence of vertical economies is to test the separability in the cost function. The rationale of this approach is the following: if separability holds, there are no benefits from integration because the integrated and disintegrated production processes are equivalent (Nemoto and Goto, 2004). Otherwise, there is an incentive for firms to integrate in order to achieve a more efficient coordination between stages that are interdependent. Roberts (1986), in a contribution focused on size and density economies, demonstrates that separability of generation and distribution can be rejected. Thompson (1997) employs a similar method (testing restrictions on the parameters of the interaction terms of the cost function) over a more recent sample, and reaches similar results, even if separated models seems to became a better fit of the data for more recent observations.

Hayashi et al. (1997) as well find evidence in favor of non-separability; the authors, using a sample of US electric utilities, test for separability of production from transmission/distribution by checking whether the capital/labor ratio of the downstream stage is independent from the price of generated energy (i.e. the intermediate good). If it is not so, the input mix of the downstream stage is affected by prices applied in the upstream stage, that implies some degree of interdependence between successive segments. The separability hypothesis is rejected by the authors in any model specification. Moreover, a measure of vertical economies is provided (0.166); no significant difference is found between average vertical economies in small and large firms.

Nemoto and Goto (2004) also perform a test of separability of production from transmission/distribution using a set of observation related to Japanese electric utilities. The aim of the test is to check whether the capital stock used in production affects transmission and distribution costs (thus it is included in the cost equation of the downstream stage). If it is so, vertical integration economies can be achieved by jointly choosing all inputs of both the stages. This is actually what emerges from the empirical analysis, as the separability hypothesis (no externality of upstream capital stock on the downstream cost) is rejected.

A second branch of studies on vertical integration uses the estimated cost function to compute the predicted values for given level of output in order to apply equation (1) (obviously, by correcting for the presence of an intermediate input). In Kaserman and Mayo (1991) we can find the first example in this sense. The authors estimate (several

specifications of) a quadratic cost function. They find that vertical economies are present over most of the relevant output range. Diseconomies arise only for very small output levels.
In Gilsdorf (1994), which employs a translog specification, instead, no evidence of cost complementarities is found between transmission, generation and distribution. However Gilsdorf (1995) applies the subadditivity test suggested by Evans and Heckman (1984) (see following section), again implemented on a translog specification. He finds no significant evidence of subadditivity of the cost function, but, however, the estimated results suggest the existence of some economies of integration, even if not sufficient to make the function subadditive. They are either vertical and horizontal, between ultimate sales and sales for resale.
More recently (2002), Kwoka investigates the same question, by means of a quadratic specification and on US data. The findings are similar to those ones of Kaserman and Mayo: economies prevail over most of the output range; diseconomies are limited to small levels of output or to cases when one output is close to zero.
Quadratic cost function specifications (random effect and random coefficient models) are also chosen by Fetz and Filippini (2010), using a panel of Swiss electricity companies. Also in this case, vertical economies exist for most of the firms in the sample, which are mainly of small and medium size.
Fraquelli et al. (2005) provide an analysis of an Italian sample by means of a composite specification. Again, vertical economies are shown to prevail, with the exception of small firms. They are very relevant for larger firms.
The contribution of Jara-Diaz et. al (2004) involves Spanish electric firms. The chosen functional form is the quadratic. The authors find vertical economies between generation and distribution. Moreover, they show the existence of horizontal economies between various sources of power generation (Coal, fuel, hydro and nuclear), significant for every product specific combination. The overall measure is particularly relevant (0.281).
Similar questions (Existence of vertical and horizontal economies) are addressed by Arocena (2008) over a similar sample (Spanish electric firms). The main difference is related to the methodology: Arocena uses a non-parametric DEA-based method to compute economies of scope. Moreover, in one specification, the author includes the quality of service as a variable to be optimized. Basically, the procedure implies the evaluation of scope economies by comparing the cost of diversified firms, taken as they were efficient with respect to their own frontier, with the cost such firms would have sustained if they were “disintegrated”, i.e. compared with the frontier of specialized firms. The results show the presence of economies for all the vertically integrated firms, independently of the inclusion of the quality variable in the model. Moreover, horizontal economies between different (thermal and hydro) generation sources are present for all the integrated firms in the model accounting for quality improvements.
Agrell and Bogetoft (2007) apply a subadditivity test on German electricity and gas distributors, which is run by comparing the efficient cost of separated activities with the efficient cost of joint operation. About the electricity suppliers, the authors find cost advantages in operating jointly activities related with different voltage levels. As the technology is not shown to allow for economies of scale, the authors infer the presence of economies of scope.
Horizontal economies of integration in distribution companies, but in a somehow particular perspective (volume and customers), are also mentioned in Growitsch et al. (2009). The authors estimate two input distance function models either including or

excluding a measure of quality of service. The results show existence of economies of scope between power supplied and number of customers for large firms. The interpretation is that a higher number of customers reduce the risk of stochastic demand effect, thus flattening the total demand faced by the firms.
The empirical evidence related to the gas sector is less rich. It is anyway possible to find some example of analyses of different kinds of integration possibilities.
Ellig and Giberson (1993) provide a contribution related to scale and scope issue in the Texas gas transmission industry. They estimate a translog cost function and investigate economies of scope between different kind of output: sales to commercial/industrial, sales for resale and transportation only. The most relevant economies are found between the two types of sale, while transportation show diseconomies when it is provided jointly with merchant activities.
Burns and Weyman-Jones (1998) investigate the natural monopoly issue in British gas supply. Their cost function estimates suggest that an increase in the supply of one output (domestic customers) with the other output (non-domestic costumers) held constant leads to a decline in the marginal cost. This findings are basically a form of horizontal cost complementarities between the two output.
Finally, a recent contribution is provided by Casarin (2007), that addresses the issue of efficient market structure in Argentina and UK's gas sector, by means of a generalized translog cost function. The aim of the contribution is to provide insights related to the efficient structure in those markets. Moreover, the vertical economies issue is considered: the author finds vertical cost discomplementarities either between the transmission and the distribution stages and between distribution and supply.
Summarizing, the problem of vertical integration has been intensively debated in the literature, especially for electricity, reflecting the relevant regulatory debate on vertical unbundling. Vertical separation seems to generate quite important efficiency losses in electricity, especially for large firms, while the studies related to the gas sector seems to show the opposite evidence. Horizontal integration *within* sectors has been until now a marginal issue, that is anyway able to provide important findings, which, in spite of being of poor regulatory interest, can provide useful guideline from the managerial perspective.
A summary of the mentioned contributions is provided in table 1 (electricity) and 2 (gas).

Table 1 – Evidence of scope economies in the electricity sector

Contribution	*Method*	*Findings*
Roberts (1986)	Cost function (Translog); test of separability	Reject the separability of distribution from transmission and generation.
Kaserman and Mayo (1991)	Cost function (quadratic)	Economies of vertical integration (generation and distribution) arise over most of the output range. Diseconomies only for very small firms. Magnitude 11.96% at the sample mean.
Gilsdorf (1994)	Cost function (translog)	No evidence of cost complementarities between transmission, generation and distribution
Gilsdorf (1995)	Cost function (translog), test of subadditivity	Weak (not significant) evidence of vertical integration economies between generation and transmission/ distribution activities. Some evidence of economies of scope between ultimate sales and sales for resale. Anyway, there is no evidence of the subadditivity of the cost function.
Hayashi, Goo and Chamberlain (1997)	Cost function; test of separability	Existence of vertical economies between between generation and distribution of power (about 0.16)
Thompson (1997)	Cost function (translog); test of separability	Reject separability of distribution or power supply from the remaining activities.
Kwoka (2002)	Cost function (quadratic)	Vertical economies between generation and distribution, especially for larger and fully integrated firms. Diseconomies for small level of output. At the sample median economies = 0.27
Nemoto and Goto (2004)	Cost function (generalized Mc Fadden); test of separability	Existence of vertical economies between generation and distribution.
Jara-Diaz, Ramos-Real and Martinez-Budria (2004)	Cost function (quadratic)	-Economies of vertical integration betwwen generation and distribution (0.065); -Economies of horizontal integration between different sources of power generation (0.09-0.1; 0.28 joint use of four sources)
Fraquelli, Piacenza, Vannoni (2005)	Cost function (composite)	Vertical economies between generation and distribution (0.03 for the average firm). Diseconomies for low levels of output.
Agrell and Bogetoft (2007)	Data Envelopment analysis	Subadditivity in operating jointly different voltage level activities in electricity distribution. As the technology is almost CRS, the subadditivity is due mainly to economies of scope.
Arocena (2008)	Data Envelopment Analysis	-Economies of vertical integration between power generation and distribution (0.017-0.051; 0.011-0.049 in the model accounting for quality of service) - horizontal economies (0.013-0.043) are clearly evident in the quality adjusted model. Evidence of some diseconomies in the cost-only model.
Growitsch, Jamasb and Pollit (2009)	Input distance function	-Economies of scope in power distribution between energy supplied and number of served customers
Fetz and Filippini (2010)	Cost function (quadratic)	-Economies of vertical integration exist over most part of the sample (small and medium sized companies)

Table 2 – Evidence of scope economies in the gas sector

Contribution	*Method*	*Findings*
Ellig and Giberson (1993)	Cost function (translog)	Horizontal scope economies exist in gas transmission. Relevant are those between sales to commercial/industrial and sales for resale (3.12). Diseconomies between transport and sale activities (-0.25). Economies of scope are more relevant for larger pipelines
Burns and Weyman-Jones (1998)	Cost function	Marginal cost fall if residential are supplied together with non-residential customers
Casarin (2007)	Cost function (generalized translog)	Cost discomplementarities between transmission and distribution and between distribution and supply

5. Telecommunications

The telecom sector as well has been concerned with separation issues, starting from the 1990s, with reference to both vertical (retail-wholesale-access) and horizontal (separation of different platforms) options (Cave, 2006). Anyway, at the present moment, the main issue is related to the vertical separation in fixed telecom between the upstream segment (potentially monopolistic, as it related with ownership of the network), especially the so-called "last mile", that provides connection with final users, from the downstream branch, involving the sale of services to customers, broadly recognized as competitive.

Following Tropina et al (2010), an important distinction has to be made between infrastructure-based and service based competition. In the former, competitors possess their own infrastructure, while in the latter they use the incumbent's one to provide their services. The former is slower to implement, and its benefits do not emerge immediately, but it is generally considered more powerful. The latter is a weaker form of competition, but it is quicker to undertake.

Once again, in the latter case, the risk is that the vertically integrated incumbent can undertake anticompetitive discriminatory behavior when granting access (mandatory, in most countries) to the network to competitors. Discrimination can take different forms, either price or non-price based. Price based discrimination take place, for instance, when the incumbent applies predatory prices in the downstream market, or provide intermediate services to competitors at higher price than the internal transfer price applied to its own downstream division. Non-price discrimination (often also named "sabotage") occurs when the discriminatory behavior is based on variables other than price, for example on the quality of the service.

Just to remain within the European Union, there are examples of completely opposite opinions related to the potential benefits of vertical separation. Just few countries have implemented such a policy, and never beyond the intermediate "functional" or "operational" form (that now operates in the UK, Sweden and Italy). Ownership separation has been considered a too strong measure, leading to major disadvantages (Cave et al. 2006):

- It is difficult to find a clear point of division, which is also likely to move over time, given the rapid evolution of the technology in this industry; moreover, in case of mistake, undoing the measure is not possible;
- Separation would make harder coordination activities and would lead to a loss of economies of scope;
- The monopoly assets will anyway require regulatory intervention, also because the separated structure would provide reduced incentive to investments, whose importance is crucial in such a dynamic industry.
- The past suggests negative experience in breaking-up telecom incumbent.

On the other hand, accounting separation is recognized as sufficient just to prevent (or to detect) price discrimination (e.g. unfair upstream prices can be detected by excessive returns of the upstream branch; predatory prices in the downstream segment can be highlighted by margin squeeze tests), but it is not powerful enough against non-price discrimination.

Therefore, functional separation has been seen as a good solution when infrastructure competition is far from being implemented and mandatory access forms such as local loop unbundling (the incumbent rents a line to the competitor, by which it can provide its own services) do not work enough effectively. However, the lack of incentive for investments and research and development remains an issue, as well as the loss of vertical economies from coordination (see Tropina et al, 2010, that highlights different authors'points).

Despite its relevance in the academic and regulatory debate, the empirical evidence on economies of scope in telecom sector is very scarce. In general, works addressing economies of scale and scope issues mainly rely on quite old data, and the rapid technological change occurring in the industry would suggest that similar analysis on updated data are likely to provide somehow different results. The issue of measuring vertical economies usually is not directly addressed. However, in most of the existing studies on scope, the synergies between local and long distance services are investigated; they actually constitute a sort of upstream and downstream segments, as long distance "products" need access to the local network to be provided. However, from the empirical perspective, such economies of scope are in general treated as "diversification", as the output on one segment is not explicitly considered as input for the other one.

A first analysis on economies of scope in Bell Canada data is provided by Fuss and Waverman (1981). They uses a translog cost function and find no significant cost complementarities among the three considered outputs: local services, message toll (long distance) services and other (competitive) services. However, the signs of the computed (non-significant) values suggest the presence of complementarities between local and toll services and between toll and competitive services, and discomplementarities between local and competitive services.

Röller (1990) employs a quadratic cost function estimated on U.S. data (Bell System). He find important economies of scope and cost complementarities between local and toll services, in both the model (with aggregated toll services or with a distinction in intra/interLATA).

Bloch et al. (2001) use a composite cost function estimated on Telstra (Australian incumbent) data, from 1926 to 1991. They find, on the basis of the value of the estimated parameters, that the economies of scope hypothesis holds between local and long distance calls.

Banker et al. (1998) estimate a multiple linear equations model for data related to US fixed telephony providers, where the dependent variables (different cost categories) are regressed on the same set of explanatory variables, that includes some indicators of joint production (scope): scope lines (business, residential, public), scope calls (local or toll) and scope geography (single or multi-state). The results show a negative impact of joint production on almost all cost categories, even if only the indicator "scope lines" is statistically significant.

Gabel and Kennet (1994) employs cost data generated by means of an optimization model to compute economies of scope between switched and non-switched (private line) service, either local and toll. They find economies of scope between switched and non-switched services to decrease with costumers density, while strong economies of scope are shown to exist within the switched branch.

Finally, there exist important and well-known contributions related to telecom industry that address the broader issue of natural monopoly. They are mainly focused on the US system and related to the debate developed around the break-up of the Bell System.

The first example is provided by Evans and Heckman (1984), that suggest a local test for natural monopoly based on the estimation of a translog cost function. The estimated parameter are used to compute predicted value for joint production of local and toll services and predicted value for disaggregated production, evaluated for different output mixes. The results show that the cost function is not subadditive.
A similar methodology is employed by Shin and Ying (1992), considering three outputs: number of access lines, local calls and toll calls. Also in this case, the evidence supports superadditivity of cost in most of the analyzed possibilities.
Diametrically different answer to the same question is provided by Charnes et al. (1988). The authors use a goal programming /constrained regression model (basically a parametric frontier model) in order to test for the presence of natural monopoly features in the Bell System; they find important efficiency gains coming from joint production rather than multi-firm production.
Summing up, what emerges from the empirical literature on telecom integration is scarce and ambiguous evidence. To the best of my knowledge the issue of economies from vertical integration of retail and wholesale activities, which would be of crucial interest in the context of the debate related to the vertical separation of fixed lines incumbents, in general is not directly addressed. Many works, however, consider economies of scope between long-distance and local services, which in principles are subsequent stages in the production chain, since the former service cannot be completed without recurring to the local network. However, local and long distance are treated as a sort of horizontal business diversification, rather than a vertically related stages, and also in this case empirical findings are controversial and seem to be strongly influenced by the method of analysis. Moreover, the rapid evolution of the technology would suggest that such kind of analysis, to be truly reliable, should be performed on more recent data.
Table 3 summarizes the mentioned empirical contributions.

Table 3 - Evidence of scope economies in the telecommunications sector

Contribution	Method	Findings
Fuss and Waverman (1981)	Cost function (translog)	None of the estimated values of cost complementarities is significant. Weak evidence of complementarities between local and message toll services and between message toll and competitive services.
Evans and Heckman (1984)	Cost function (translog)	Multifirm production more efficient than single-firm production of local and toll services
Charnes, Cooper and Sueyoshi (1988)	Goal programing/ constrained regression (frontier metod)	Efficiency gains coming from the provision of local and toll services by means of a unique firm rather than by multiple firms.
Röller (1990)	Cost function (quadratic)	Important economies of scope and cost complementarities exist between local and toll services.
Shin and Ying (1992)	Cost function (translog)	In 67% of the tested combination, multifirm production is advantageous compared to single-firm production of access lines, local and toll services
Gabel and Kennet (1994)	Optimization model	Economies of scope between switched and non-switched services, decreasing with customer density; strong economies within the switched branch (between local and toll services)
Banker, Chang, Majumdar (1998)	Linear multivariate model	Indicators of joint production negatively affect costs in most cases. Only the scope effect of different lines (single business, multiple business, public, residential) is statistically significant
Bloch, Madden and Savage (2001)	Cost function (composite)	Economies of scope between local and long distance calls.

6. Water

The water sector has not been, until now, too much concerned with unbundling issues; rather, there are cases where regulatory reforms have exerted some pressure towards integration of water utilities, as happened in Italy with Galli's Act in 1994. In general (with the exception of England), the water industry is still seen as a natural monopoly. This is so notwithstanding the similarity between water and other sectors such as electricity, where the vertical separation of the potentially competitive stages has been broadly applied. This situation is highlighted in Garcia et al. (2007): the authors investigate the magnitude of economies of vertical integration between water "production" and distribution, whose existence would justify the lack of pressure towards vertical unbundling. They use a sample of US water utilities and estimate separate translog cost functions for integrated and non-integrated companies. The findings show the presence of relevant vertical economies for small firms only. Moreover the authors try to isolate the component related to pure technological economies (i.e. netting out the effect of transaction costs or of inefficient input allocation), and the obtained results are similar.

A different picture is drawn by the study of Stone and Webster (2004), commissioned by OFWAT, the regulatory authority for England and Wales. They estimate both a translog and a quadratic cost function. The outputs proxy water production and distribution (water service) and sewerage treatment and connections (sewerage service); the models include hedonic variables accounting for quality. The findings show vertical economies between water supply and distribution, while diseconomies emerge between sewerage collection and treatment.

However, the main question addressed in the literature involves the economies of scope that can be achieved by means of the horizontal integration of water and sewerage services. It is worthwhile to point out that, although sewerage can be seen as a "downstream" stage in the water cycle, it is not so from an economic perspective, as it does not use as an input the output of the previous stage (water supply). Therefore the integration between water and sewerage services is horizontal, rather than vertical. The prevailing findings from the literature say that economies of scope are absent between the two services. A relevant contribution in this sense is again provided by Stone and Webster (2004). The findings show overall diseconomies of scope between water supply and sewerage. However some economies exist between production/treatment activities (of drinking and wastewater), and between connection related activities (water distribution and wastewater collection), which are likely to be due to the use of similar input.

Similar finding had already been shown in Hunt and Link (1995), for the period before privatization: no cost complementarities emerged between water supply and sewerage. However economies were present between water supply and environmental services, that are no longer provided by water operators after the reform. The estimates are provided by means of a dynamic cost function that in some of the tested specification accounts for quality of service adjustments.

Not too different are the conclusions reached by Saal and Parker (2000), that estimate a translog cost function. The computed jointness parameter does not allow to reject the hypothesis of non-jointness in the provision of water and sewerage activities, i.e. there is no evidence of the existence of economies of scope. However this parameter change sign turning from positive to negative in quality adjusted specification; this fact provides, in the authors' opinion, some weak evidence in favor of the existence of "quality driven" scope economies, which could at least partially offset the costs related to quality improvements. Also this contribution, as well as the previous one, is related to firms operating in England and Wales.

Marques and De Witte (2011) employ a non-parametric method based on the estimation of FDH frontier models over a sample of Portuguese water utilities. By comparing the efficiency estimates of a conditioned (on a "scope" index) and a non-conditioned model they deduce the influence of scope: firms providing jointly water and sewerage services are not more efficient than water only companies.

Nevertheless, there exist some contributions providing the opposite evidence, i.e. detecting economies of scope between the two segments. Turning to investigation related to England and Wales, Link (1993), also in this case working on pre-liberalization data, estimates a frontier cost function and finds important economies of scope among water, sewerage and environmental services, even if the magnitude is reduced in the quality-adjusted specification. The negative sign of the interaction term suggests cost benefit coming from the joint provision of water supply and sewerage.
In a more recent contribution, Nauges and Van Den Berg (2008) estimate cost functions for water utilities operating in four developing countries (using translog specifications including quality-related variables). The analyzed countries are Brazil, Moldova, Romania and Vietnam; in all but the last countries utilities provide both water and sewerage services and economies of scope are shown to exist.
Fraquelli and Giandrone's study (2003) is focused on estimating a cost function over a sample of Italian wastewater treatment plants. The adopted functional form is a Cobb-Douglas including some quality measures of the treated water. They also include a variable to control for the integration with water supply services, which is shown to be significant and to negatively affect cost, thus suggesting the presence of economies of scope.
However the characteristics of the water industry allow for other definition of horizontal scope economies. For instance, Torres and Morrison Paul (2006) detect high economies of scope between the production of water for retail (sales to final customers) and wholesale (sales to other utilities) market, that are particularly relevant for smaller firms. Estimates are provided over a sample of US water utilities by means of generalized Leontief quadratic cost function and accounting for endogeneity of the output.
Kim (1987) and Kim and Clark (1988) also provide contributions on the cost structure of US water utilities for the year 1973. The authors use a translog cost function, overcoming the problem of dealing with zeros by substituting them with arbitrarily small level of output (10% of the sample mean). About the scope problem, they find a negative effect in term of cost complementarity between residential and non-residential services, i.e. the positive values of cross marginal cost elasticicities suggest that increasing one output generate an increase in the marginal cost of producing the other output. Nevertheless, in Kim and Clark (1988) the estimates highlight the existence of economies of scope (0.1663) at the sample mean, which however are not likely to persist over the whole output range. The shape of the M-locus (the set of all points with minimum ray average costs) as well provide evidence in favor of economies of scope.
Table 4 summarizes the reviewed contributions.

Table 4 – Evidence of scope economies in the water sector

Contribution	*Method*	*Findings*
Kim (1985)	Cost function (translog)	Positive "cross" marginal cost elasticities between residential and non-residential services
Kim and Clark (1988)	Cost function (translog)	-Economies of scope at the sample mean (0.1663) between residential and non-residential services -Positive cross marginal cost elasticities
Link (1993)	Frontier cost functions (logarithmic form)	Existence of important cost complementarities in the joint production of water supply, sewerage and environmental services (59%; 21% in the specification introducing quality adjustment)
Hunt and Lynk (1995)	(Dyanmic) cost functions (logarithmic form)	Cost complementarities between environmental services and water supply. Negative effect of integrating sewerage.
Saal and Parker (2000)	Cost function (translog)	Not possible to reject the hypothesis of non-jointness (no significant cost savings related to joint provision of water and sewerage)
Fraquelli and Giandrone (2003)	Cost function (Cobb-Douglas)	The variable capturing integration of wastewater treatment plants with water supply services in the treatment cost function is negative, suggesting the presence of economies of scope.
Stone and Webster (2004)	Cost function (Quadratic and translog)	-Horizontal overall diseconomies of scope between water supply and sewerage; -Horizontal economies between water and sewerage productions and connection related activities -Vertical economies between water production and distribution (for WOCS) -Vertical diseconomies between sewerage collection and treatment
Torres and Morrison Paul (2006)	Cost function (Generalized Leontief Quadratic)	Important economies of scope between wholesale and retail water production, especially relevant for small firms (.45 at the sample mean, .75 for small firms)
Garcia, Moreaux, Reynaud (2007)	Cost function (translog) different for integrated and separate firms	-vertical economies between water production and distribution, significant only for small firms -Also technical economies are important only for small firms
Nauges and Van der Berg (2008)	Cost function (translog)	Scope economies between water supply and sewerage in three countries (Brazil, Moldova and Romania)
Marques and De Witte (2011)	FDH	No evidence of scope economies between water supply and sewerage (integrated firms are not more efficient than water only utilities)

7. Multiutilities

It is quite common that services such as gas, electricity, water, etc. are provided by single diversified firms. We call such kind of firms "multiutilities". Their importance and number increased after the privatization and liberalization reforms of the last decades. As highlighted by Fraquelli et al. (2004), on the one hand, entrants in the newly liberalized market started exploring the opportunity of providing services previously reserved to the incumbent. On the other hand, incumbents started to operate out from their core business to react to the loss of market share due to increased competition. Diversification is also an appealing opportunity for small firms in order to saturate their capacity when growth perspectives in their core business are limited. However the authors point out that by selling bundles of outputs, multiutilities can increase their market power. This is the main argument in favor of the implementation of horizontal unbundling. In fact, while some degrees of vertical unbundling have been broadly promoted by regulators in many network industries, horizontal separation in multiutilities is still an open question. The recognized advantage (see. Farsi et al., 2008, and Filippini and Farsi, 2008) would be the introduction of stronger and more transparent competition; however, looking for instance to EU recommendations on this topic, the importance of evaluating potential synergies among sectors is recognized; moreover, they exempt small utilities (less than 100,000 customers) from any separation requirement. This approach is coherent with the main findings of the literature, that show that economies of scope between gas, power and water provision actually exist and they are more relevant for smaller utilities.

Sing (1987) estimates a translog cost function with Box-Cox transformation of the output variables to overcome the problem of dealing with zero levels of outputs. The sample includes both firms that are specialized or integrated in the supply of electricity and gas. The author finds that economies of scope exist for some level of output, without identifying a clear relation between firm dimension and gains from joint production. At the sample mean, diseconomies of scope (-0.072) occur.

Mayo (1984) and Chappell and Wilder (1986) analyze as well multiutilities providing gas and electricity. Both the contributions rely on estimates based on quadratic cost functions. The findings are similar: in both the cases the authors show that there is room for economies and diseconomies of scope, depending on the level of output, but economies arise for smaller firms. Mayo finds that the positive sign of the interaction coefficient between the two outputs indicates discomplementarities from joint production. Therefore when positive economies of scope occur it is due to the sharing of fixed costs. Chappell and Wilder provide also estimates over a restricted sample, excluding electric firms exploiting nuclear technology. With this correction, that should homogenize the technological characteristics of the analyzed firms, they find that economies of scope prevail over most of the output range.

More recent contributions are provided by Piacenza and Vannoni (2004) and Fraquelli, Piacenza and Vannoni (2004). They analyze a sample of Italian utilities providing water, gas and electricity distribution, either separately or as integrated firms. The former contribution is more focused on the choice of a functional form, supporting the suitability of Pulley and Braunstein's composite against other specifications (standard translog, generalized translog and separable quadratic). They find evidence of global economies of scope for the median firm. The latter paper, while testing the same functional forms, is more concerned with the scale and scope properties of the multiutility technology. About the scope issue, the authors find that economies of scope prevail either globally or by the product-specific analysis. However they are significant only up to the median level of output. The most relevant product-specific economies occur with the joint production of gas and water.

In Farsi et al. (2008) and in Filippini and Farsi (2008) an analysis of the Swiss multiutility sector is provided. As for the previously mentioned contributions, the firms included in the sample operate in water, gas and electricity supply. In the former article the authors estimate a GLS and a random coefficient specification of a quadratic cost function. They find that economies of scope exist except for the largest firms (where almost no scope effect is detected). Moreover, their magnitude is larger for smaller utilities. The latter study employs a frontier technique, that allow for efficiency evaluation that is one of the main goals of the contribution. Moreover, the natural monopoly issue is investigated. Since the authors use a translog cost function (implementing different models: GLS, Pitt and Lee, Battese and Coelli, Greene's true random effects), it is possible just to report cost complementarities. There is weak evidence of the presence of cost complementarities, mainly regarding the interaction of electricity with the other outputs.

Summing up, the empirical evidence related to multiutilities suggests that there is room for cost savings coming from integration. However, the presence of synergies strongly depends upon the level of output: small utilities seem to benefit more of economies of scope, probably because diversification is a way to better saturate their capacity, since they cannot enjoy the scale effect, as larger firms do. Table 5 summarizes the results of the analyzed contributions.

Table 5. Evidence of scope economies in the multiutility sector

Contribution	Method	Findings
Mayo (1984)	Cost functions (quadratic)	Both economies and diseconomies of scope in electricity and gas supply. Economies for low level of output. The positive sign of the output interaction term indicates cost discomplementarities.
Chappell and Wilder (1986)	Cost function (quadratic)	Both economies and diseconomies of scope in electricity and gas supply. When excluding utilities exploiting nuclear technology, economies prevails over most of the output range. They are especially relevant for low level of output.
Sing (1987)	Cost function (translog with Box-Cox transformation)	Both economies and diseconomies of scope in electricity and gas supply. Diseconomies (-0.072) at the sample mean.
Piacenza and Vannoni (2004)	Cost functions (standard translog, generalized translog, separable quadratic, composite)	Economies of scope from joint supply of gas, water and electricity for the median firm.
Fraquelli, Piacenza, Vannoni (2004)	Cost functions (standard translog, generalized translog, separable quadratic, composite)	Economies of scope from joint supply of gas, water and electricity (0.124 at the median output). Larger economies for smaller firms. Economies are not significant for output level larger than the median. Product-specific economies of scope are higher between gas and water.
Farsi, Fets and Filippini (2008)	Cost functions (quadratic)	Economies of scope between water, electricity and gas distribution, especially relevant for small firms. Magnitude 0.12 (RC model), 0.17 (GLS model) at the sample median
Filippini and Farsi (2008)	(Frontier) cost function (translog)	Existence of (weak) cost complementarities between water, electricity and gas distribution (pairs of outputs)

8. Quality of service

Consumers' welfare is related, in public utilities as in other industries, not only to the prices consumers face, but also to the quality of the service provided. For this reason QoS (Quality of Service) is (and must be) an issue for regulators, as cost efficiency and competition are. This is especially relevant when price regulation involves incentive mechanisms such as price-cap, since they are aimed to improve firm's cost efficiency. In such regulatory frameworks, firms receive an incentive to cut their costs, including quality-upgrading ones, unless the regulator imposes specific quality targets to be achieved and a correct penalty mechanism in case of non-compliance (see for instance Weisman, 2005).
QoS assumes different meanings depending on the industry it is related. In electricity, for instance, it involves mainly continuity of service. In the literature usually it appears with measures of bad quality such as the number or the duration of interruptions.
In the studies related to the water sector, the issue involves both water and service quality. The former indicators are concerned with the chemical and biological characteristics of the drinking water (for distribution) or of treated water (for sewerage and treatment). The latter are related to other characteristics affecting the customer satisfaction, such as continuity of service or sufficient pressure of the supplied water. Moreover, pipe breaks or network losses are sometimes considered.
Finally, in telecom industry, quality of service is measured mainly by means of customer satisfaction indicators, such as timely installations, time of intervention in case of troubles, complaints to the regulator. However, in some cases, a measure of network modernization is used as a proxy, even if it can be seen more as mean (to provide better quality services) rather than as an end in itself.
The potential link between firm integration and QoS is not largely debated in the literature on public utilities, even if the problem is relevant from the customer's welfare perspective. Firm integration can affect QoS in different ways. For instance, when the technology favors joint production, integrated firms are able to operate more efficiently and to save resources that can be utilized for quality improving investments. Moreover, in the debate related to vertical integration and unbundling, it has emerged that separation would reduce the incentive to invest, and investments drive QoS maintenance and upgrading. For example, in relation to the telecom sector, in Tropina et al. (2010), it is mentioned that the (functional) unbundling of the incumbent would reduce its incentive to make infrastructure and R&D investments. Basically, the reason is that in case of separation the returns of such investments would not be fully appropriable for the incumbent itself, and this would lead to an amount of expenditure below the (social) optimal level.
About the telecom industry, the contributions involving QoS are mainly related to the effect of incentive regulation (see for instance Sappington (2002), Resende and Façanha (2005), or Sappington (2003) for a review). Scarcer is the empirical evidence connecting QoS and economies of integration. Among the contribution reviewed in section 5, just Shin and Ying (1992) include in the analysis a measure for network modernization (electronic access lines). Arocena (2008) and Growitsch et al. (2009) provide "quality adjusted" models for electricity including the ICEIT (Installed Capacity Equivalent Interruption Time) indicator and the average duration of outages per customer, respectively, as measures of (bad) quality. Finally, among the mentioned works on the water companies, Link (1993) and Hunt and Link (1995) use indicators of water and sewerage quality as control variable, as do Saal and Parker (2000) and Fraquelli and Giandrone (2003) (the latter focusing on

wastewater). Stone and Webster (2004) consider both water and service quality in their analysis. Nauges and Van der Berg (2008) include measures of duration of supply and pipe breaks.
What results from the existing literature is that the quality issue, in spite of its welfare relevance, is not largely considered in empirical studies on public utilities, especially in those related to costs and opportunities coming from integration. Nevertheless, there exists interesting examples suggesting useful ways of how to treat this problem, whose development should be encouraged in future research.

9. Conclusions

The recent tendency towards privatization and liberalization in public utilities has shed light on the economics of public services in general. Among other issues, the matter of integration and unbundling has been debated. This work, after having analyzed the definition, the potential sources and the method of estimating economies of scope, has presented the problem of integration and separation in some important public services. Quite surprisingly, the first sector that has been historically involved with (vertical) unbundling issues, electricity, is also the one presenting more consistent findings in favor of the presence of vertical economies between generation and distribution stages, whose reliability is supported by several contributions on this matter. Different kinds of horizontal economies have also been investigated, either at the generation and the transmission stages, and the results again support integration as an efficient choice. Studies related to the gas sector, which as well has been involved in vertical unbundling, show that the technology does not favor vertically integrated firms. However, the literature on this topic is scarcer. More controversial results emerge from the empirical literature on the water sector, which has never been too concerned with separation issues. One of the most debated question is the existence of horizontal economies between water supply and sewerage services; even if empirical answer are ambiguous, the existence of diseconomies (or at least no economies) of scope between the two branches seems to be the prevailing finding. Moreover, there is some evidence supporting the presence of vertical economies between water production and distribution, at least for some levels of production.
Water, electricity and gas (or two among them) are often supplied jointly by means of multiutilities companies. The empirical evidence is quite unanimous in suggesting that in the technology there is room for both economies and diseconomies of integration, depending on the firms size. Usually economies arise for small firms.
The most controversial findings involve the telecommunication industry. The sector is now involved in an important debate related to the costs and opportunities of implementing vertical separation of the incumbent firm in fixed telephony. Nevertheless, the empirical literature on integration in telecom is scarce; even if a number o f studies investigate the synergies between local and long distance services, in principle vertically related stages, the evidence is ambiguous. Moreover, the existing literature bases its findings on data which are not recent, which constitutes an important drawback in an industry whose technology evolves very rapidly. Despite the importance of the topic, I could not find a recent work in telecom assessing the existence of vertical economies.

Quality of service is also mentioned in this work, because it plays a role at least as important as firm efficiency or market competition in term of consumers' welfare. Empirical literature related to QoS is not scarce, but contributions connecting it to utilities integration or economies of scope are. In general, quality measures are quite often added as control variables in studies related to water sector, probably because of their evident relevance in term of health implications, but the same does not hold for the other analyzed industries. Nevertheless, the literature provides useful suggestions on how to deal with this kind of question, whose importance, from both the regulatory and the managerial perspective, suggests that it could be an interesting field for future research.

References

Agrell, P., Bogetoft, P. (2007). "Development of benchmarking models for German electricity and gas distribution". Final report. Project no. 730. *Sumicsid AB*
Online at:
http://www.bundesnetzagentur.de/cae/servlet/contentblob/88060/publicationFile/1932/GutachtnSUMICSID-Id9598pdf.pdf

Arocena, P. (2008) "Cost and quality gains from diversification and vertical integration in the electricity industry: a DEA approach". *Energy economics*, 30, pp.39-58.

Banker, R.D., Chang, H.H., Majumdar, S.K. (1998). "Economies of scope in the U.S. telecommunications industry". *Information economics and policy,* 10, pp.253-272.

Baumol, W.J., Panzar, J.C., Willig, R.D. (1982). "Contestable markets and the theory of industry structure". *Harcourt Brace Jovanovich,* New York.

Bloch, H., Madden, G., Savage, S.J. (2001). "Economies of scale and scope in Australian telecommunications". *Review of industrial organization*, 18, pp. 219-227.

Bogetoft, P., Wang, D. (2005). "Estimating the potential gains from mergers". *Journal of productivity analysis,* 23, pp. 145-171.

Burns, P., Weyman-Jones, T. (1998). " Is the gas supply market a natural monopoly? Econometric evidence from the British Gas Regions". *Energy economics,* 20, pp. 223-232.

Casarin, A.A. (2007). "Efficient industry configurations in downstream gas markets. An empirical assessment". *Energy economics*, 29, pp. 312-328.

Cave, M., Correa, L., Crocioni, P., (2006). "Regulating for non-price discrimination. The case of UK fixed telecoms". Online at:
http://web.si.umich.edu/tprc/papers/2006/526/non-price2.pdf

Cave, M. (2006). "Six degrees of separation. Operational separation as a remedy in European telecommunications regulation". *MPRA paper no. 3572.*
online at http://mpra.ub.uni-muenchen.de/3572/

Cave, M. (2010). " Snake and ladders: unbundling in a next generation world". *Telecommunication policy,* 34, pp. 80-85

Chappell, H.W., Wilder, R.P. (1986). "Multiproduct monopoly, regulation and firm costs: comment". *Southern economic journal,* vol. 52, no.4, pp. 1168-1174

Charnes, A., Cooper, W.W., Sueyoshi, T. (1988). "A goal programming/constrained regression review of the Bell system breakup".

Ellig, J., Giberson, M. (1993). “Scale, scope, and regulation in the Texas gas transmission industry”. *Journal of regulatory economics,* 5, pp. 79-90.

Evans, D.S., Heckman, J.J. (1984). “A test for subadditivity of the cost function with an application to the Bell system”. *The American economic review,* vol.74, no.4, pp. 615-623.

Evans, D.S., Heckman, J.J. (1986). “A test for subadditivity of the cost function with an application to the Bell system - erratum”. *The American economic review,* vol.76, no.4, pp. 856-858.

Evans, D.S., Heckman, J.J. (1988). “Natural monopoly and the Bell system: response to Charnes, Cooper and Sueyoshi”. *Management science,* vol.34, no.1, pp-27-38.

Farsi, M., Fetz, A., Filippini, M. (2008). “Economies of scale and scope in the Swiss multi-utilities sector”.
The energy journal, 29,4, pp. 123-143

Filippini,M. Farsi M.(2008) *Cost Efficiency and Scope Economies in Multi-output Utilities in Switzerland*. Strukturberichterstattung Nr. 39, State Secretariat of Economic Affairs (SECO), Bern, Switzerland.
Available at: www.seco.admin.ch

Fetz, A., Filippini, M. (2010) “Economies of vertical integration in the Swiss electricity sector”. *Energy economics*, 32, pp. 1325-1330.

Fortin, M., Leclerc, A. (2006) “An output orientated non parametric measure of economies of scope”. *Groupe de recherché en économie et développement international,* n. 06-22.

Fraquelli, G., Giandrone R. (2003). “Reforming the wastewater treatment sector in Italy: implications of plant size, structure, and scale economies”. *Water resource research,* vol.39, no.10, pp. 1-7.

Fraquelli, G., Piacenza, M., Vannoni, D. (2004). “ Scope and scale economies in multi-utilities: evidence from gas, water and electricity combinations”. *Applied economics,* 36, pp. 2045-2057.

Fraquelli, G., Piacenza, M., Vannoni, D. (2005) “ Cost savings from generation and distribution with an application to Italian electric utilities”. *Journal of regulatory economics,* 28, pp. 289-308.

Fuss, M., Waverman, L. (1981). “Regulation and the multiproduct firm: the case of telecommunications in Canada”. In *Studies in public regulation,* ed. By G. Fromm, Cambridge: MIT Press, 277-313.

Gabel, D., Kennet, D. M. (1994). “Economies of scope in the local telephone exchange market”. *Journal of regulatory economics,* 6, pp. 381-398.

Garcia, S., Moreaux, M., Reynaud A. (2007). “Measuring economies of vertical integration in network industries: an application to the water sector”. *International journal of industrial organization,* 25, pp. 791-820.

Gilsdorf, K. (1994). “Vertical integration efficiencies and electric utilities: a cost complementarity perspective”. *Quarterly review of economics and finance,* fall 1994*,* pp.261-282.

Gilsdorf, K. (1995). “Testing for subadditivity of vertically integrated electric utilities”. *Southern economic journal*, vol. 62, no.1, pp. 126-138.

Grosskopf, S., Hayes, K., Yaisawarng, S. (1992) “Measuring economies of diversification: a frontier approach”. *Journal of business & economic statistics,* vol.10, n.4, pp. 453-459.

Growitsch, C., Jamasb, T., Pollit, M. (2009). “Quality of service, efficiency and scale in network industries: an analysis of European electricity distribution”. *Applied economics,* 41, pp. 2555-2570.

Growitsch, C., Wetzel, H. (2007) “Testing for economies of scope in European Railways: an efficiency analysis”. *University of Luneburg, working paper series in economics,* n.72.

Hayashi, P.M., Goo, J. Y.-J., Chamberlain, WM.C. (1997). “Vertical economies: the case of U.S. electric utility industry, 1983-87”. *Southern economic journal,* vol. 63, no. 3, pp. 710-725.

Howell, B., Meade, R., O’Connor, S. (2010). “Structural separation versus vertical integration: lesson for telecommunication from electricity reforms”. *Telecommunication policy, 34, pp. 392-403.*

Hunt,L.C., Link, E.L. (1995). “Privatisation and efficiency in the UK water industry: an empirical analysis”. *Oxford bulletin of economics and statistics*, 57, 3, pp. 371-388.

Jara-Diaz, S., Ramos-Real, F.J., Martinez-Budria, E. (2004). “Economies of integration in the Spanish electricity industry using a multistage cost function”. *Energy economics,* 26, pp. 995-1013.

Kaserman, D.L., Mayo, J.W. (1991). “The measurement of vertical economies and the efficient structure of the electric utility industry”. *The journal of industrial economics,* vol. 39, pp. 483-502.

Kim, H.Y. (1987). “Economies of scale in multi-product firms: an empirical analysis”. *Economica,* vol. 54, no. 214, pp. 185-206.

Kim, H.Y., Clark, R.M. (1988). “Economies of scale and scope in water supply”. *Regional science and urban economics,* 18, pp. 479-502.

Kwoka, J.E. (2002). “Vertical economies in electric power: evidence on integration and its alternatives”. *International Journal of industrial organization,* 20, pp. 653-671.

Link, E.L. (1993). “Privatisation, joint production and the comparative efficiencies of private and public ownership: the UK water industry case”. *Fiscal studies*, vol. 14, n.2 pp. 98-116.

Marques, R.C., De Witte, K. (2011). “Is big better? On scale and scope economies in the Portuguese water sector”. *Economic modelling,* 28, pp. 1009-1016.

Mayo, J.W. (1984). “Multiproduct monopoly, regulation and firm costs”. *Southern economic journal,* vol.51, no. 1, pp. 208-218.

Montgomery, C.A. (1994) “Corporate diversification”. *The journal of economic perspectives*, vol.8, n.3, pp. 163-178.

Nauges, C., Van den Berg, C. (2008) “Economies of density, scale and scope in the water supply and sewerage sector: a study of four developing and transition economies”. *Journal of regulatory economics,* 34, pp. 144-163

Nemoto, J., Goto, M. (2004). “Technological externalities and economies of vertical integration in the electric utility industry”. *International journal of industrial organization,* 2, pp.67-81

Panzar, J.C., Willig, R.D. (1981) “Economies of scope”. *The American economic review,* vol. 71, n.2, pp. 268-272.

Penrose, E. (1959). “The theory of the growth of the firm”. *Oxford: Basil Blackwell*

Piacenza, M., Vannoni, D. (2004). “Choosing among alternative cost function specifications: an application to Italian multi-utilities”. *Economics letters,* 82, pp. 415-422.

Resende, M., Façanha, L.O. (2005). “Price-cap regulation and service-quality in telecommunication: an empirical study”. *Information economics and policy*, 17, pp. 1-12

Roberts, M.J. (1986). “Economies of density and size in the production and delivery of electric power”. *Land Economics,* vol. 62, n.4, pp. 378-387.

Röller, L.-H. (1990). “Proper quadratic cost functions with an application to the Bell System”. *The review of economics and statistics,* vol. 72, no.2, pp. 202-210

Saal, D.S., Parker, D. (2000). “The impact of privatization and regulation on the water and sewerage industry in England and Wales: a translog cost function model”. *Managerial and decision economics,* 21, pp. 253-268.

Sappington, D.E.M. (2002). “Price regulation and incentives” in *Handbook of telecommunication economics (EdS)* M. Cave, S. Majumdar, and I. Vogelsang, North Holland, Amsterdam pp. 225-93.

Sappington, D.E.M. (2003). “The effect of incentive regulation on retail telephone service quality in the United States”. *Review of network economics*, vol. 2, issue 4, pp. 355-375.

Shin, R.T., Ying, J.S. (1992). "Unnatural monopolies in local telephone". *The RAND journal of economics,* vol. 23, no.2, pp. 171- 183

Sing, M. (1987). "Are combination gas and electric utilities multiproduct natural monopolies?". *The review of economics and statistics,* vol.69, no.3, pp. 392-398.

Soares, I., Sarmento, P. (2009). "Telecommunication, electricity, and natural gas sector unbundling: how far should it go?". *Second annual conference on competition and regulation in network industry,* Centre for European policy studies, Brussels, Belgium.

Stone & Webster (2004). "Investigation into evidence for economies of scale in the water and sewerage industry in England and Wales". *Stone and Webster consultants*
Online at: http://www.ofwat.gov.uk/pricereview/pr04/pr04phase1/rpt_com_econofscale.pdf

Thompson, H.G. (1997). "Cost efficiency in power procurement and delivery service in the electric utility industry". *Land economics,* vol.73, no.3, pp. 287-296.

Torres, M., Morrison Paul, C.J. (2006). "Driving forces for consolidation or fragmentation of the US water utility industry: a cost function approach with endogenous output". *Journal of urban economics,* 59, pp.104-120.

Tropina, T., Whalley, J., Curwen, P. (2010). " Functional separation within the European Union: debates and challenges". *Telematics and informatics, 27, pp. 231-241.*

Vareda, J. (2010). "Access regulation and the incumbent investment in quality-upgrades and in cost-reduction". *Telecommunication policy,* 34, pp.697-710.

Weisman, D.L. (2005). "Price regulation and quality". *Information economics and policy,* 17, pp. 165-174.