UNIVERSITÀ DEGLI STUDI DI BERGAMO

Faculty of engineering

PhD Program in Economics and Management of the Technology

XXIV cycle

Vertical and horizontal integration in public utilities. Evidence from telecom EU operators and Italian water regulatory agencies

Supervisor: Prof. Luigi Buzzacchi

PhD dissertation Clementina BRUNO

January 2012

I gratefully acknowledge the patient supervision and helpful advice of Professor Luigi Buzzacchi.
Moreover, I would like to thank the research group I have been collaborating with at "Università del Piemonte Orientale", in particular Prof. Giovanni Fraquelli, for his support and his useful and original insights. A special thanks goes to Dr. Fabrizio Erbetta, always present during the whole PhD period to give his irreplaceable technical and moral support.
I also wish to thank Prof. Per J. Agrell of the "Université Catholique de Louvain", that has supervised my activity during my period abroad, for the useful technical in-depth advice in the methodologies I have employed in this work.
My gratitude also goes to the coordinator, Prof. Gianmaria Martini, and to the other members of the PhD committee, for their support and their useful insights.
Finally I want to thank my PhD collegues, that, with their presence, support and friendship, made unforgettable these last three years.

SUMMARY

INTRODUCTION

Mono-product firms are often considered in economic modeling, but constitute an exception, rather than the rule, in the real production systems. In general what we observe is the presence of firms producing different outputs. Firms integrate because they have some incentives to do so. Excluding the managerial tendency towards empire building (which is not driven by profit-maximization reasons), such incentive can be related to two main reasons. The first one is the possibility of achieve productivity gains by exploiting synergies of joint production (mainly, economies of scope), while the second one is related to the wish to increase market power. From consumers perspective, such motivations work in diametrically different directions: higher productivity reduces firms costs and, potentially, can lead to lower final prices; higher market power usually act in the opposite sense.

The public utilities industry is a particular one (because it is related to services broadly considered as "essential" for the population; because, for decades, it has been characterized by the presence of (often, public) monopolies; because, even after liberalization, these sectors show some monopolistic features, mainly related to the fact that they are network-based; because, finally, they are regulated, at least after the privatization process recently undergone in many countries) where the issues of economies of integration and the need to limit firms' market power are relevant concerns for regulators, which act in order to protect consumers' welfare. In general, the target of improving competition has been of primary importance, and, sometimes, dis-integrating incumbents (previously the monopolists) has been used as a powerful tool in this sense. These policies of business separation (unbundling) have been involved in a relevant debate aimed to compare the competition gains with the productive efficiency losses, especially in term of economies of integration.

This work will treat the problem of integration in public utilities. The empirical part will focus on the cost perspective (economies of integration) and will employ frontier techniques. It is composed of three chapters.

The first chapter has the structure of a literature review. The aim of the survey is not to be exhaustive. Rather, it will provide a general presentation of the problems of integration and unbundling in some important network services (energy, gas, telecoms, water and multiutilities) and it will identify the areas where the literature is scarcer. Broad space will be devoted to the empirical studies on the economies of scope. Moreover, the quality of service issue will be treated.

The second chapter will provide an empirical analysis of economies of vertical integration in fixed telecommunications; as it emerges from chapter one, this is a relevant issue in the present moment, as the sector is concerned with separation issues. Nevertheless, the empirical studies in this sense are very scarce. The empirical analysis will employ a non-parametric methodology based on Data Envelopment Analysis (DEA).

The third chapter is somehow a particular one, as it will test the effect of integrating regulatory agencies rather than firms. The involved regulators are the Italian Water authorities and the estimation method will employ both a parametric (stochastic frontier) and a non-parametric (DEA) in order to estimate *ex-ante* the gains coming from mergers.

CHAPTER 1.

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

1.1 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 1.3 explains the definition and the methods of evaluation of economies of scope. Section 1.4, 1.5, 1.6 and 1.7 analyze the integration and unbundling issues for energy, telecom, water and multiutilities sectors, respectively. Section 1.8 introduces the problem of quality of service. Section 1.9 draws some conclusions.

1.2 Vertical and horizontal integration in public utilities.

Integrated firms are able to provide multiple output. 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 firms 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.

1.3 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:

$$SC = \frac{C(Y_1,0)+C(0,Y_2)-C(Y_1,Y_2)}{C(Y_1,Y_2)} \qquad (1.1)$$

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 example 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 to compute the cost complementarity component. Broadly used cost function 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 Färe, 1986, introducing a DEA method for computing economies of scope. About the related empirical applications, see for instance Arocena, 2008, for a contribution on electricity; Growitsch and Wetzel, 2007, for railways. Bogetoft and Wang, 2005, illustrate a theoretical presentation and a practical application of a particular method to compute size and mix economies: Fortin and Leclerc, 2006, introduce 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.

1.4 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 1.1 (electricity) and 1.2 (gas).

Table 1.1 – 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 1.2 – 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

1.5 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 1.3 summarizes the mentioned empirical contributions.

Table 1.3 - 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)	Multi-firm 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.

1.6 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 isolate the component related just to technological economies (netting out the effect of transaction costs or of inefficient input allocation), obtaining similar results.

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 emerges 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 elasticities 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 1.4 summarizes the reviewed contributions.

Table 1.4 – 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)

1.7 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 prevails 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 specifications 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 1.5 summarizes the results of the analyzed contributions.

Table 1.5. 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)

1.8 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 customers 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 customers 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 firms 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. Firms 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.

1.9 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 contribution 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 of 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.

CHAPTER 2.

FUNCTIONAL SEPARATION AND ECONOMIES OF VERTICAL INTEGRATION IN EUROPEAN FIXED TELECOMS

2.1 Introduction

During the last decades the telecom industry, as many other utilities, has been involved, in most developed and developing countries, in a privatization and liberalization process. In order to foster competition in sectors which have been operating as monopolies for a long time, many Governments and regulators have implemented unbundling (separation) policies of the incumbent firms, with the aim to separate the segment of the production chain showing monopolistic features. Once separated from the rest of the company, the access to the bottleneck infrastructure (in general, the network) should be granted under equal conditions to the incumbent firm and to the competitors, improving (service-based) competition.

As explained in the previous chapter, the segment showing monopolistic characters in telecoms, because it is difficult and costly to replicate, is the network, especially the "last mile" (the local access network), that the incumbent possesses and that the competitors need to access in order to provide their service to the final users. The separation of this segment is involved in a relevant debate. The European Union has considered functional separation as a solution to foster competition and grant equal and fair condition of access to the last mile to competitor firms, when mandatory access imposed on the incumbents does not work effectively. Some member States have shown a positive attitude towards this opportunity (e.g. Ireland, Latvia, Poland, etc. For a deep discussion, see Tropina et al. , 2010 and Crandall et al., 2010), but the cases where functional separation has already been implemented are very limited.

UK has been the first country moving in this direction. In 2005, the negotiation between the regulator and the incumbent (British Telecom, BT) leaded to the creation of a separate BT business unit, Openreach, in charge of operating the local access network and of providing the related wholesale services either to the BT retail branch and to the competitors.

In Italy the first steps in this direction are rooted in 2002, when AGCOM, the regulator, directed Telecom Italia (TI) towards the creation of distinct retail and wholesale business units. However, the most significant change occurred in 2008. During that year, the powers of AGCOM expanded: the Italian legislation conferred the regulator the power to impose functional separation. TI, then, voluntarily created a separated unit, OpenAccess, following the line of Openreach[1]. At the end of 2008, AGCOM approved the measure.

2008 has been a crucial year also for the Swedish telecom market. The regulator, PTS, received from the Parliament the power to impose functional separation on the incumbent TeliaSonera. Even before the law was approved, TeliaSonera (also in this case, voluntarily) implemented functional separation by creating a wholly owned subsidiary, TeliaSonera Skanova Access, that provides access to the incumbent's network both to the competitors and to the downstream branch of the parent company.

Strong and broadly accepted theoretical reasons support functional separation as a mean to foster competition; however (and, again, in theory), such a solution could in principle generate important drawbacks, in terms of reduced incentives to investment and innovation, and in term of losses of (vertical) economies of scope. Whether or not the competition benefits offset the efficiency losses is mainly an empirical question, whose answer requires to quantify both the gains and the costs. The aim of this work is to provide a contribution with respect to the costs side:

Q: Is functional separation in fixed telecoms costly in terms of losses of economies of vertical integration?

To answer this question, a non-parametric DEA-based methodology will be applied over a sample of 14 European operators, with data over the period 2005-2010. The dataset contains cost and operational information on integrated and functionally separated firms. Two model specifications will be tested: a basic model that simply distinguishes wholesale and retail activities, and an improved model accounting for different quality of access (narrow band and broadband) provided to the final users.

The rest of the paper is organized as follows. The next section introduces the competition issues in fixed telecommunications and clarifies the *pros* and *cons* of functional separation; section 2.3 provides a definition of economies of vertical integration and reviews some empirical contributions addressing the problem of economies of scope in telecommunications; section 2.4 presents the methodology; section 2.5 illustrates the dataset and the variables employed in the

[1] However Open Access deals directly only with TI retail division, not with the competitors, that must ask for services to the wholesale division. This one and other transparency issues are discussed in Nucciarelli and Sadowsky, 2010.

two model specifications; section 2.6 discusses the results, while section 2.7 draws some conclusions.

2.2 Background

As previously mentioned, the competition issue in fixed telecommunications is related to the presence of a downstream segment (retail, involving the provision of services to the final users) which is, at least potentially, competitive, and of an upstream segment (wholesale, or more precisely, the access infrastructure, i.e. the so-called “last mile”) which shows some monopolistic features.

As a first step, it is important to distinguish between two definitions of competition (see Tropina et al., 2010). It is *infrastructure based* when the competitors do not rely (at least, not relevantly) on the access infrastructure of the incumbent, because they possess their own one. It is the most powerful form of competition, but it requires long time to be implemented and strong investment on the side of the competing firms. Therefore, as a quicker solution, many Governments and regulators’ efforts are directed to foster *service based* competition. In this case the competitors use the incumbent firm’s access network to provide their services. The level of required investment is reduced and the development of a competitive market is faster, but there are some drawbacks: for instance, the necessary regulatory effort is relevant, because the authority has to impose some forms of mandatory access (e.g. local loop unbundling, LLU) on the incumbent, in order to grant the competitors the possibility to access the last mile at fair conditions. On the regulator side, this is not a simple task: the incumbent has the incentive, and in general also the ability, to engage anticompetitive behaviors, basically in the form of price and non-price discrimination. The former consists in charging excessively high wholesale prices on competitors (thus rising their costs) or in applying predatory prices to its own retail customers, in order to drive new entrants out of the market. Non-price discrimination has the same target, but relies on tools different from price (for instance, the quality of the service offered to the other firms), and is also identified as “sabotage”.

Regulators have seen in some forms of business separation an effective way to deter and to detect such undesirable behaviors. To use the consolidate taxonomy suggested in Cave (2006), a first step is accounting separation, which requires just separate accounts for the separated branches, in order to allow the regulator to detect too high wholesale margins or too low retail profits (indicating too high access prices applied to competitors or predatory prices in the downstream segment, respectively). If price discrimination can be effectively dealt with by implementing this solution, non-price discrimination remains an unsolved issue. More pervasive forms of separations seem necessary in this sense. The extreme solution of ownership separation (the incumbent has to divest the bottleneck segment, which cannot belong to the same ownership as the rest of the firm) has been implemented in some countries for other network industry (e.g. electricity). However it is not considered suitable for telecoms (see Cave et al., 2006), for several reasons, among which it is important to notice the impossibility to exploit of economies of scope and coordination across the ownership boundary and the reduced incentives to invest[2].

Functional or operational separation [3]is seen as an intermediate solution, effective against non-price discrimination and able to limit the disadvantages of more pervasive forms of break-up. It can itself be ranked in several degrees, ranging from the creation of a wholesale division to legal separation (separate entities under the same ownership). As discussed in Tropina et al. 2010, to provide a definition, separation occurs with respect to functions, employees and information.

In this framework, it is reasonable to question whether some of the disadvantages mentioned in Cave et al. (2006) for ownership separation are likely to occur also implementing this softer option, even in a weaker form. For instance, the impossibility to share production factor (which in principle could be common between stages) such as labor, or to transfer information relevant for coordination activities could produce inefficiencies in term of loss of economies of vertical integration. Moreover, the separated functions would operate as distinct decision units. Therefore the upstream unit's incentive towards investments whose returns are not fully appropriable would be reduced. Finally, the availability of the bottleneck assets for competitors at favorable conditions is, on one hand, useful to foster service-based competition; nevertheless, on the other hand, it reduces the incentive of new entrants to invest in their own infrastructure, thus delaying the implementation of infrastructure-based competition, broadly recognized as superior.

It emerges that it is relevant, from a regulatory perspective, to identify the potential *pros* and *cons* of a break-up policy, even if implemented in a "softer" form such as functional separation.

[2] The authors highlight also the difficulty in establishing a clear and stable point of break-up, which is impossible to be moved in case of mistake, and the fact that (except the separation of AT&T), structural separation operations in telecoms have often failed.

[3] The distinction between the two definitions is still quite fuzzy; in general here we will define as "functional" separation all the options lying between accounting and ownership separation.

Moreover, it is relevant to understand the magnitude of gains and costs, which must be correctly balanced. The aim of this work is to evaluate the costs, if any, in term of losses in economies of vertical integration, of the implementation of functional separation in European Countries. If such economies did not exist or were not relevant, this would constitute and argument in favor to functional separation, as this solution would benefit consumers through improved competition (which is likely to induce lower prices), without hurting them with efficiency losses in the production of the service, which ultimately would impact negatively by raising the final tariff. If such economies were relevant, instead, they would represent a relevant cost of a separation policy, which should be implement only if the gains in term of competition were large enough to offset those efficiency losses.

2.3 Economies of vertical integration and the telecom industry

The economies of vertical integration (EVI, henceforth) can be though as a special case of economies of scope. Following Baumol, Panzar and Willig (1982), economies of scope are said to exist if the joint production of several outputs is cheaper than the production of the same outputs by means of separated specialized firms. The measure, in the case of two distinct vertical stages (and two outputs), can be expressed as

$$EVI = \frac{C(y_u, 0) + C(0,\ y_d) - C(y_u, y_d)}{C(y_u, y_d)}$$

Where y_u indicates the output of the upstream stage, y_d indicates the output of the downstream stage and $C(.)$ represents the cost of producing a certain output vector.

$EVI > 0$ indicates economies of vertical integration, $EVI < 0$ indicates diseconomies.

EVI in fixed telecom is not a debated in issue in empirical works. In particular, to the best of our knowledge, this work is the first one addressing the question of the existence of EVI in EU incumbent operator after the implementation of separation policies.

Even if the issue of vertical economies between the wholesale and retail segments is, in general, not explicitly addressed in the empirical literature on economies of scope in telecoms, there exist some interesting contributions assessing the synergies between local and long distance (toll) services, which reflect, in principle, the same vertical relationship. In fact, the long distance provider need to access the local network, which usually belong to the local operators. These works are mainly developed with reference to the US market in the context of the debate concerning the break-up of AT&T. Therefore, they rely on quite old dataset; moreover, the findings are controversial.

For instance, Evans and Heckman (1984) suggest a local test for natural monopoly based on the estimation of a translog cost function. The estimated parameters are used to compute the predicted value of cost 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.

On the other hand, it is possible to find several studies offering evidence in favor of integration.

Röller (1990) finds important economies of scope and cost complementarities between local and toll services by testing two models model (with aggregated toll services or with a distinction in intra/interLATA). He uses a quadratic specification of the cost function.

Charnes et al. (1988) employ 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 with respect to multi-firm production.

Banker et al. (1998) estimate a multiple linear equations model, 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, thus including “scope calls”, even if only the effect of the indicator “scope lines” is statistically significant.

Gabel and Kennet (1994) employ 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 the economies of scope between switched and non-switched services to decrease with costumers density, while stable strong economies of scope are shown to exist between local and long-distance services within the switched branch.

Moreover, to mention some non-US based contribution, it is important to recall Fuss and Waverman's (1981) work, using data related to Canadian operators. 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.

Finally, evidence in favor of the existence of scope economies is provided by Bloch et al. (2001). The authors 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.

As it emerges from the analysis of previous studies, there is not consistent evidence of the existence of economies of scope in fixed telecom: the results are quite controversial and sensitive to the methodology employed. Moreover, as mentioned above, the analyses rely on old datasets, while the rapid evolvement of the technology would suggest that the findings could change by employing more recent data.

2.4 Methodology.

In this work we will employ a non-parametric method to compute EVI. It is based on Data Envelopment Analysis (DEA) and employs a two stages procedure, which will be illustrated below. The use of DEA methods to estimate economies of scope has been introduced by Färe (1986). Later, similar approaches have been used, among the others, by Arocena (2008), for electricity; Ferrier et al. (1993), for banking; Prior (1996), Fried et al. (1998), Prior and Solá (2000), Kittelsen and Magnussen (2003), concerning hospitals; Grosskopf and Yaisawarng (1990), on local public services; Kwon and Yun (2003), on cogeneration; Cummins et al. (2003), on insurance; Growitsch and Wetzel (2007), on railways.

The basic idea is to construct two different frontiers: one for integrated firms, providing both the upstream and the downstream outputs; a second frontier is constructed for "specialized firms". In many of the above mentioned contributions, the specialized firms (providing only one of the considered outputs) are combined, i.e. summed, in order to create virtual "additive" units producing output vectors similar to those ones produced by the integrated firms; by doing so, the technology defined by summing the specialized firms does not reflect joint production; rather, it conserves the productivity characteristics of the specialized production technologies.

Let us analyze the procedure. First of all, the N units are divided in two groups: the group I of integrated (not separated) firms, and the group S of “combined” separated firms. Moreover we have:

c_n= input (cost) of firm *n*, *n = 1, ..., N*

Y_n= output (vector) of firm *n*

J, H = (S,I)

Stage 1. For each firm n, we need to get the efficiency score computed with respect to its own frontier, which can be defined as:

$$E_n^j = E_n\left(c_n^J, Y_n^J\right) = \; Min\,\{E_n| \;\; (E_n c_n, \; Y_n)\epsilon \; T^J\}$$

This is computed by means of a standard DEA program, and we expect to get $E_n^J \leq 1$.

Stage 2. For each firm n, we need also the cross-frontier efficiency score, i.e. the efficiency score each firm get when compared to the frontier constructed with respect to the firms belonging to the other group:

$$E_n^h = \; E_n\left(c_n^J, Y_n^J\right) = \; Min\,\{E_n| \;\; (E_n c_n, \; Y_n)\epsilon \; T^H\}, \qquad H \neq J$$

This is computed by solving a super-efficiency DEA program. It allows to exclude from the frontier the unit under evaluation, i.e. the firm receives an efficiency score but does not contribute to define the shape of the production possibility set. For this reason, in this stage E_n^h is not constrained to be smaller or equal to one.

After the second stage each firms possess two efficiency score: E_n^S, computed with respect to the separated firms frontier, and E_n^I, computed with respect to the integrated firms frontier. These values allow to compute the EVI.

Starting from the definition of economies of vertical integration presented in section 3, and following Arocena (2008), we will get, for each one of the considered units:

$$\text{EVI} = \frac{C(y_u,0)+C(0,y_d)-C(y_u,y_d)}{C(y_u,y_d)} = \frac{E_n^S * c_n - E_n^I * c_n}{E_n^I * c_n} = \frac{E_n^S}{E_n^I} -1. \qquad (2.1)$$

Where

- The term "$E_n^S * c_n$" represents the efficient cost (i.e. the observed cost projected on the frontier, as it is multiplied by the efficiency score) of producing the output vector of the considered firm by means of the "separated" technology.
- The term "$E_n^I * c_n$" represents the efficient cost of producing the same output vector by means of the "integrated" technology.

Clearly, if the (efficient) joint production is cheaper than the (efficient) separated production, economies of vertical integration occur (EVI>0). Diseconomies would result in the opposite case.

Such an approach presents some relevant advantages:

- it is implemented in a non-parametric (DEA) framework, which has the desirable features of not imposing any pre-specified functional form and of being suitable for small dataset, which is actually our case.
- It employs a frontier technique, therefore no cost-minimizing behavior is assumed *a priori*; rather, the existence of inefficiency is allowed for. Following Grosskopf et al (1992), this is an interesting feature, because it allows to compute economies and diseconomies of integration on the "pure" technology, "cleaned" from the inefficiency effect that could distort the results.
- Two separated frontiers are constructed for integrated and separated firms; in this way we do not assume that the two groups operate under the same technology; rather, the existence of two different production possibility sets is allowed for.

In Figure 2.1 a two inputs (x1 and x2) case is represented. It is relevant to point out that this is not the case of the two models proposed in this work. Anyway, such a representation is helpful to better understand the methodology.

The two isoquants represent all the efficient combinations of inputs allowing to produce a given level of output by means of a joint (I) or of a separate (S) production technology, respectively. Let us assume that firm A is a functionally (vertically) separated firm operating with some degree of inefficiency, as the input consumption is higher than the efficient one, represented in the point C, that lies on the (separated) frontier isoquant. The efficiency score of firm A would be $E_A^S = \frac{\mathrm{OC}}{\mathrm{OA}}$, which express the maximal proportional contraction that can be applied to the input and still allows to produce the given output.

If we compute E_A^I, the efficiency score of firm A with respect to the frontier I, i.e. $\frac{\mathrm{OB}}{\mathrm{OA}}$, we would get an higher ratio, because the segment OB is longer than the segment OC. In other words, we will have $E_A^I > E_A^S$.

This is so because the integrated production technology (bounded by the frontier I) is "internal" to the separated one, in the sense that some of the production combinations allowed by the technology S are not feasible in I. This is evident by looking at the relative position of the two frontier: S requires, for a given level of output, an always lower quantity of x1 or x2, or of both the factors. This means that it is more efficient to produce using technology S rather than technology I; in other words, diseconomies of vertical integration occur.

In fact, if we compute the values of the EVI for firm A following (1), we will get

$$\text{EVI} = \frac{E^S}{E^I} - 1 = \frac{OC}{OA} / \frac{OB}{OA} - 1 < 0 \qquad \text{as OC < OB}$$

Clearly, no *a priori* assumption is made on the relative position of the two frontiers. The case depicted in figure 1 will always lead to detect diseconomies of vertical integration (negative EVI). It can also happen the position of I and S to be inverted: this is the case of vertical economies. Moreover it is possible that the two frontiers intersect each other, and we will find, over the sample, both economies and diseconomies.

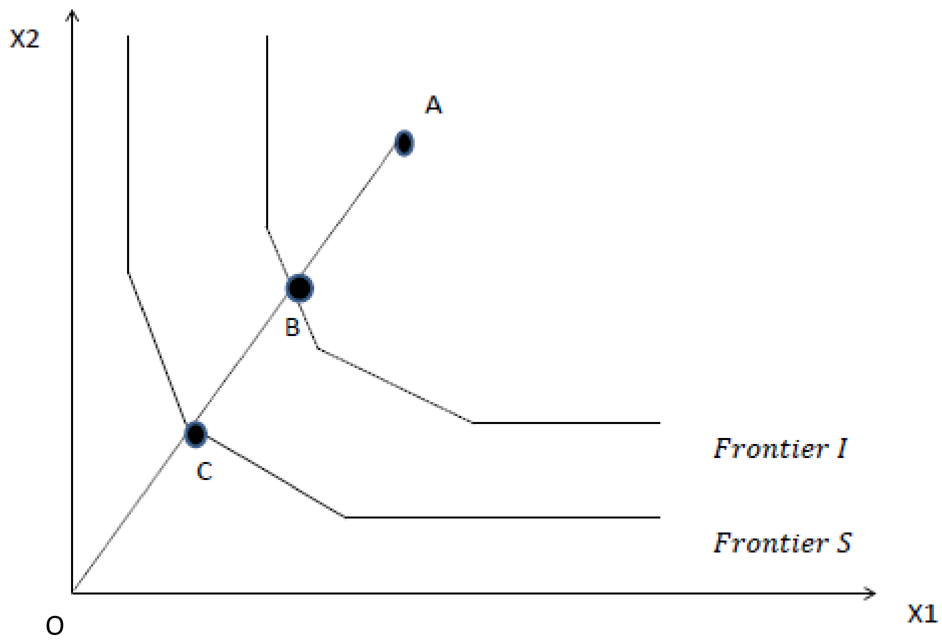

Figure 2.1

2.5 Data, variables and models.

The dataset is composed of observations over 14 European incumbent operators in fixed telecommunications and contains financial and operational information retrieved from the companies' annual reports. We have chosen to restrict the analysis to the incumbent firms because they are the companies involved in separation operations. Moreover, usually non-incumbent operators do not possess the access network, not producing the relative wholesale output; therefore their output vectors are not completely comparable with the incumbents' ones.

The financial years from 2005 to 2010 are included. Most of these companies operate in both the fixed and the mobile markets, but we have chosen to focus on the fixed branch operations, because it is the market concerned with the separation issues illustrated above. Therefore we did not include in the sample many operators as they do not provide separate accounting (cost) information for the fixed segment. Moreover, for the included companies, such information is not available over the whole period. As a result, the sample contains a total of 62 observations.

For each company, we collected the data starting from 2005 or 2006, i.e. from the year of the first application of the IFRS accounting standards. This should ensure higher longitudinal (among different financial periods) and cross-company comparability of the collected data. Moreover, we focus on the operation in the home country. The reason is that many of the companies in the sample are controlled or participated by other ones which are as well included in the dataset, and which consolidate the former in the group accounts. The exclusion of the operations in foreign countries avoids the problem of attributing the same costs and outputs twice, to the controlled and to the controlling company.

The group of separated units is composed of three firms: Telecom Italia, British Telecom and TeliaSonera. In many of the contributions mentioned in the previous section which apply similar methodologies, the "separated" group is composed of virtual units created by summing the data of the specialized firms (firms producing only, or mainly, the upstream or the downstream output). Such an approach would be interesting and useful in order to increase the number of observations, which in our case is low (13 available observations), by constructing all the possible combinations of the wholesale and the retail specialized units. Anyway this solution would require to adjust ("clean") the separated units for the "internal" transfer of the intermediate output and for the related "internal" cost. Unfortunately, as the separated entities still belong to the parent company (division) or to its group (subsidiary), the necessary information is not reported in the annual reports of these groups, with the exception of BT. For this reason, we are forced to consider the cost and the output variable as they appears in the annual reports, which net out the internal cost and output, thus providing the variables already "corrected" (i.e., in the needed form), but making impossible to construct permutations between units. Therefore, the separated firms technology is estimated through units that produce both the upstream and the downstream output, but with the awareness that they operate under functional separation restrictions.

This fact generates also an advantage: the separated units are real, rather than "virtual", firms, therefore it make sense to estimate the EVI (as "potential" EVI lost as a consequence of functional separation) also over this segment of the sample.

The group of integrated units is composed by the observations related to the remaining firms (49 observation).

Table 2.1 contains a list of the firms included in the sample, with the indication of the country of origin.

Table 2.1 – Companies and countries

COMPANY	COUNTRY
Separated firms group:	
Telecom Italia	Italy
TeliaSonera	Sweden
British Telecom	UK
Integrate firms group:	
Telefónica	Spain
France Telecom	France
Deutsche Telekom	Germany
OTE	Greece
TEO	Lithuania
Belgacom	Belgium
Eirecom	Ireland
Polish Telecom	Poland
Telekom Austria	Austria
Portugal Telecom	Portugal
KPN	Netherlands

The methodology illustrated in the previous section is implemented in two slightly different models.

Model 1. It is a one input – two outputs model. The unique input is the total operational cost, composed as the sum of material and services expenditure, labor cost and depreciations. The cost is expressed in constant 2005 prices. Moreover, in order to correct for the difference in the prices level among the considered countries, the total value is converted using the Purchase Power Parity (provided by EUROSTAT). In principle, such a problem could be more effectively dealt with by using "physical", rather than monetary, measures of input (number of employees, network length, etc.); however the small dimension of the sample, especially in relation to the separated firms group, suggest to implement a model as parsimonious as possible; therefore the inputs have been condensed in a single variable. Moreover, the necessary information on physical production factors is not available for all the companies, therefore the choice of including such variables would have caused a further reduction in the number of observations. Finally, reasoning in term of "cost" is consistent with the traditional definition of economies of scope.

The two outputs must reflect the upstream and the downstream operations. The most relevant indicator available for all the firms is the number of access lines. Therefore the two considered output measures are:

- The total number of wholesale accesses (provided to other operators by means of local loop unbundling, wholesale line rental, etc.)
- The total number of retail accesses provided to the final customers.

As in Arocena (2008), the observations are pooled, i.e. each observation is treated as an independent unit in order to construct an inter-temporal best practice frontier, as explained in Tulkens and Vanden Eeckaut (1995). This procedure also allow to operate with a sufficient number of observations.

The DEA programs are run under the CRS assumption, as we want to net out all the possible sources of inefficiency, i.e. technical and scale inefficiency. Moreover, it allows to avoid problems in dealing with the super-efficiency estimates, as the super-efficiency program could have no solution if VRS were assumed.

Model 2 follows almost entirely model 1, except for the fact that the retail output is split in narrow band and broadband accesses. The underlying idea is that not all the retail lines present the same quality in terms of customer utility. Moreover, telecom companies receive pressure also from the regulatory side to increase the penetration of the broadband. Finally, it is likely that the higher quality of the broadband output is reflected in a higher resource consumption. Summing up, the variables appearing in model 2 are:

- total cost, as defined in model 1, as input;
- total wholesale accesses (which in principle could as well be divided in narrow and broadband; unfortunately, the information is not available for all the firms. Moreover, the number of observations is not sufficient to deal with one more dimension);
- “low-quality” retail accesses: narrow band lines provided to the final customers (e.g. traditional PSTN lines)
- “high-quality” retail accesses: broadband lines provided to final customers (e.g. DSL lines).

The two proposed models are very similar, anyway it is interesting to undertake both the approaches in order to understand whether or not accounting for qualitative difference in the provided services has an impact on the final results.

Table 2.2 provides some descriptive statistics of the variables. It emerges a relevant variability that depends mainly on the different size of the analyzed firms.

Table 2.2. Descriptive statistics

	Mean	St.Dev.	Min.	Max.
Tot. cost (euro millions)	6335	5971	250	20340
Wholesale accesses (thousands)	3646	4560	35	16221
Retail accesses (thousands)	14132	13203	689	44800
Broadband retail accesses (thousands)	3149	3079	102	12100
Narrowband retail accesses (thousands)	10983	10398	477	37900

2.6 Results

From the application of the described methodology, it is possible to get, as an “intermediate” result, the efficiency scores of the observed units. As table 2.3 shows, on average, the efficiency scores are slightly higher for the separated firms group in both the models. As we are analyzing the efficiency measures computed, for each unit (observation), with respect to its own frontier, we still cannot say whether the firms in group S are more efficient than firms in group I. This result just means that, on average, the separated units lie closer to the frontier, while the integrated ones are more dispersed.

Table 2.3. Average efficiency scores and average by year.

	MODEL 1		MODEL 2	
	Separated	Integrated	Separated	Integrated
mean	80,06	75,94	85,11	81,23
2005	-	69,40	-	77,17
2006	63,85	70,54	66,40	74,77
2007	69,78	71,19	73,80	75,03
2008	77,99	78,63	83,88	84,10
2009	86,07	79,11	91,82	85,52
2010	93,79	87,27	99,64	90,80

Moreover, dealing with observations related to different years allows to highlight a trend: the efficiency scores are, on average, increasing over the considered time period. The tendency is confirmed either by model 1 and model 2 (except for year 2005 in model 2, in relation to group I) and suggests the presence of a technological improvement, which seems to be faster and more evident for group S. By examining the individual efficiency scores, not reported in the table, it emerges that this trend holds for all the separated firms, while the integrated ones do not show such a clear tendency.

Let us turn to the examination of the estimated economies of vertical integration, summarized in table 2.4 (the EVI are reported for each firm as average over the available period).

Table 2.4. Average EVI by firm

FIRMS	EVI M1	EVI M2
Separated firms		
Telecom Italia	-0,27	-0,20
TeliaSonera	-0,28	-0,28
British Telecom	-0,47	-0,45
Integrated firms		
Telefonica	-0,19	-0,17
France Telecom	-0,26	-0,25
Deutsche Telecom	-0,24	-0,20
OTE	-0,24	-0,25
TEO	-0,19	-0,05
Belgacom	-0,19	-0,21
Eirecom	-0,29	-0,25
Polish Telecom	-0,20	-0,18
Telekom Austria	-0,19	-0,10
Portugal Telecom	-0,19	-0,21
KPN	-0,36	-0,35
mean	-0,25	-0,21

Quite surprisingly, at least from a theoretical perspective, negative EVI (diseconomies) result from both the models and present, on average, relevant values (more than 20%). This result should be interpreted, for integrated firms, as an higher cost sustained because of joint provision of wholesale and retail services; for the S group, instead, the EVI indicator expresses the savings firms achieve by operating under functional separation. Putting it differently, separated firms are able to produce more efficiently. It is relevant to point out that these losses and savings do not apply to the observed cost level of the firms: it is the effect vertical integration or disintegration would induce to the units if they operated efficiently, i.e. on the frontier.

The EVI indicators estimated by means of model 1 are quite stable (20-30%), with the exception of British Telecom that presents higher values. The stability is maintained also when we consider the value of the indicator computed for the single observations (not reported in the table).

By looking at the results of model 2, it emerges an higher variability in the EVI indicator, which is on average lower in terms of absolute value; in other words, diseconomies of integration still prevail, but they are smaller and less stable across firms. Only two companies, Belgacom and Portugal Telecom, present higher diseconomies. Having a look to the EVI value for single observations, the variability is even higher, with a few cases (4 observation) where the sign changes (small economies: around 2%).

Paying attention to the composition of the output, it emerges that the increase in the EVI indicator is higher the more the firms are concentrated on the broadband service: the correlation coefficient between the increase in EVI across models and the percentage of broadband access provided is about 80%. This fact emerges also having a look to the weights assigned to the outputs in solving the DEA primal problem: the units assigning higher value to the broadband present lower diseconomies or, in some extreme cases, small integration economies. Basically, when the broadband output becomes more important, the two frontiers get closer. Then, it appears that on average separated firms operate by far more efficiently than the integrated ones, but they become relatively less good once more advanced services must be supplied.

Summing up, from the empirical analysis, the following points emerge:

1) The separated firms increase their efficiency level over time more (and more quickly) that integrated firm do.
2) The separated firms are able to operate more efficiently than the integrated ones: by comparing the two frontiers, it emerges that the separated production technology is superior over the whole sample in model 1, and over most of the sample in model 2. This suggests that the technology does not present synergies of joint production. This fact is quite surprising in an industry that has traditionally been operating with integrated firms. However, it looks much less surprising keeping in mind that the firms now operating under functional separation have chosen to implement this policy more or less voluntarily: the potential benefits obtainable over time having satisfied the regulators' proposal are

summed to the advantages coming from a more productive production structure. However, if diseconomies of integration of this magnitude really characterize the sector, it is not clear why all the other incumbent firms do not undertake separation strategies. Perhaps, notwithstanding the regulatory efforts, vertical integration still allows to retain substantial market power granting the incumbents monopolistic rents offsetting the effect of vertical diseconomies.

However, the superior efficiency of the separated technology can have other sources than "pure" economies of vertical integration. For instance, it is possible that the S group companies, in implementing functional separation, have also re-organized their way to operate, by solving congestion problems or eliminating other latent sources of inefficiency; this could easily be the case since these incumbent firms have enjoyed some degrees of discretion in the re-organization process.

Finally, it is possible that the implementation of functional separation, by encouraging new entries, or, at least, by generating the expectation of new entries in the future, provides an incentive to the incumbent firms to improve their performance: the competitive pressure (or the threat of an increased competitive pressure) often leads the firms in the market to operate more carefully on the cost side.

3) The magnitude of diseconomies decreases when, on the output side, a distinction is made between narrow and broadband accesses, and firms concentrate more on broadband services. This fact suggest that, although separation remains, at least on average, the most efficient way to operate, when advanced services such as broadband assume more weight in terms of output mix, the separated firms loose part of their relative advantage. A possible explanation is that the provision of advanced services (and, probably, this is especially the case in the starting phases) requires to share production factors and, perhaps more relevantly, information flows across vertically related stage. When "Chinese walls" are built between subsequent segments, this task becomes harder generating efficiency reductions.

The general idea emerging from the analysis strongly support functional separation policies: not only they generate gains in term of competition, but they also induce improvements, rather than losses, in terms of economies of scope. Clearly, nothing can be said with respect to the reduction of the incentive to invest both on the incumbent and of the competitor side, which is the other major drawback of separation policies. Anyway, if the efficiency gains coming from separation actually depended only on the presence of "pure" diseconomies of scope characterizing the technology, the interest in providing incentive to the new entrants to invest in their own network (to reach the utopic situation of completely infrastructure- based competition) would be questionable. In fact, it would lead to a market composed of many vertically integrated operator, whose performance would suffer of efficiency losses due to negative EVI. Rather, it could be the case to consider the opportunity to further foster service-based competition and to promote separation as a best practice solution.

2.7 Conclusions

Functional separation in fixed telecommunication is, at the present moment, involved in a relevant academic and non-academic debate. The aim of implementing such a policy is to foster service-based competition, which would ultimately benefit consumers through lower prices. However, some potential drawbacks have been pointed out: the reduction of the incentives to invest (both on the incumbent and on the new entrants sides) and the possible losses in production efficiency due to the inability to exploit economies of scope. This work is concerned with the latter issue: it is aimed to check whether the implementation of functional separation in some European Countries has been costly in terms of economies of vertical integration.

The empirical analysis is performed by means of a DEA-based methodology allowing to estimate the value of EVI by computing and comparing, for each firm, two efficiency scores, evaluated with respect to the separated and to the integrated technology frontiers, respectively.

Two models have been implemented: a basic model that simply distinguishes wholesale and retail outputs, and an improved model that considers different quality levels in the downstream output, treating narrow band and broadband accesses as distinct variables.

The findings show that separation is not costly from an efficiency perspective; rather, diseconomies of vertical integration emerge from both the models (more that 20%, on average). This fact can be related to the technological features characterizing the industry (we would have detected "pure" diseconomies), but can also be related to other reasons. For instance, the companies, in implementing functional separation, have undertaken an organizational restructuring that could have been helpful in improving performance by eliminating latent inefficiency sources, not necessarily related to the vertical structure of the firm. Moreover, it is likely that the increased competitive pressure following separation (or the incumbents' expectations in this sense) acts as an incentive leading to improve the efficiency level.

Whatever the cause ("pure" vertical diseconomies, re-organization, competitive pressure, or a mix of the three factors), it emerges that separation positively affects incumbent performance, sustaining the arguments in favor of the implementation of such a policy choice.

However, if model 1 is completely consistent with these results, model 2 presents more variability in the estimated EVI indicators. The level of diseconomies is (on average) lower than in model 1, and the difference is more evident (with some extreme cases where small economies are detected) for the units more concentrated in the provision of the broadband output. This means that, although on average separate production is superior, its relative advantage is reduced (or, even, disappears) when firms focus on more advanced services. It could be related to the fact that the provision (or, at least, the implementation) of advanced services requires production factors or, more likely, information to flow freely across subsequent operational stages; separation limits these possibilities of "circulation", and this fact could act reducing the separation advantages.

However, it is worthwhile to point out that, from a policy perspective, our results should be taken cautiously, considering the limited dimension of the sample, especially in relation to the group of the separated firms. In this sense, we think that it could be helpful to extend the analysis by including more operators, perhaps non-European, as some form of separation have been recently implemented also out of the EU (e.g. Australia and new Zeland). In this case it would probably be necessary to control for the impact of environmental factors, and this could constitute an interesting development of this work.

CHAPTER 3.
REORGANIZING ITALIAN WATER SECTOR: POTENTIAL GAINS FROM AUTHORITIES INTEGRATION.

3.1 Introduction

The Italian water sector has undergone major modifications since the implementation of the reform promoted with the law no. 36/1994 (Galli's Act, henceforth), which had the target to reduce the fragmentation of the water supply and sewerage services in the country (provided in the '90s by more than 9000 firms and municipalities) and to improve the quality of the service (e.g. by reducing the number and duration of interruptions and the water losses along the network, and by increasing the number of sewerage connections). In order to achieve such targets, the country has been divided into 92 "Optimal Territorial Areas" (OTAs, or ATO in Italian). In each one, a single integrated firm should have been in charge of providing the water and sewerage services, thus being able to achieve larger efficiency by exploiting economies of scale and scope. To prevent potential abuses of the firm (clearly a monopolist) on the consumers, in each area a regulatory authority (Optimal Territorial Area Authority, or OTAA) has been established, with tasks mainly related to long run economic planning and control activities. Such a system, with industrial providers and regulatory bodies, was evidently inspired to the British one. However it presented a peculiarity: the one-to-one relationship between controller and controlled firm. Such a rare (or unique) case in regulation leaded to a total number of 92 regulatory authorities in the country, operating without any central coordination.

Recently Italian OTAAs have been abolished by law (n. 42/2010), even if they will operate until the end of 2011. Italian regions are now in charge of reorganizing the system and re-attributing the regulatory tasks previously performed by the OTAAs. In such a framework, this contribution is able to provide helpful policy suggestions, since its purpose is twofold.

The first point is the following. The existence of a regulation authority is aimed to guarantee to customers accessible prices and good quality of service, which (the former especially) are not likely to be achieved in an unregulated monopolistic framework. However, also the authority is a resource-consuming entity, whose cost ultimately burdens the consumers, either through the tariffs or through the tax system. Therefore whether or not the authority is using its resources efficiently is one of the relevant questions addressed in this work:

Q1: Are (were) Italian water authorities efficient?

The second point is related to the large number of OTAAs created in the country, which constitutes an Italian peculiarity, and to the fact that the system is going to be restructured after OTAAs' abolition. Moreover, during the last months, policy makers have shown the intention of aggregating small local authorities, as a part of the proposed measures aimed at the reduction of the public expenditure. In such a context, a quite natural question is whether merging water authorities (which are both small and local ones) can lead to cost savings and therefore can be considered as a possible way of restructuring the system. Then, the second issue considered here is:

Q2: Are there potential cost gains from merging Italian OTAAs?

In order to answer these questions, the methodology presented in Bogetoft and Wang, 2005 (B&W), will be employed. It is a method that, starting from a traditional efficiency analysis over the sample (which will provide the answer to Q1), can test the potential gains or losses of aggregating some of the units (as requested in Q2). Moreover, such gains can be decomposed in pure technical efficiency potential, harmony (scope) and size (scale) effect.

The paper will proceed as follows: the following section describes OTAAs characteristics and tasks; section 3.3 presents some reference literature about performance analysis of regulators; in section 3.4 the method of analysis is explained; section 3.5 illustrates the estimation procedure; in section 3.6 the data and the variables are described; section 3.7 presents the results, while, finally, section 3.8 draws some conclusions.

3.2 Italian water authorities.

Italian OTAAs, as implemented by Galli's reform, are regulatory authorities in charge of controlling the activity of the firms providing the service over the Optimal Territorial Areas. Originally it was thought as a crucial aspect of the reform that the provider should have been unique in each OTA, but in practice there have been some cases in which the regional law has allowed the presence of multiple operators. In general, however, we can think to a one-to-one relationship between the authority and the firm.

The Authorities are small entities, either in the sense that they operate at local level and because they are small offices: on average OTAAs employ 6 people, and in general not more than 18, with some cases with a single employee. This dimensional peculiarity has both advantages and drawbacks. A relevant advantage is that local bodies have better knowledge of the territory. A second point is related to the fact that small size assures in general higher flexibility, due to lower impact of bureaucracy.

The main disadvantages are either in terms of the overall costs (multiplication of similar activities across entities with the same tasks, inability to completely exploit fixed factors) and in terms of the effectiveness of OTAAs work (small authorities are more likely to be "captured" by the controlled firms and to suffer political pressure from local public entities, such as municipalities and provinces).

OTAAs' mission, in a long term perspective, it to preserve water as a resource for future generations. On a medium time horizon, they have mainly planning and control tasks.

Planning activities are mainly economic. Authorities fix prices, by applying a method defined by law and which is common over the country and employs a price-cap mechanism. In doing so, the OTAAs must take into account the need of investments in the area, which has to be evaluated starting from the observed state of the infrastructure and in order to achieve at least minimal quality targets. Moreover, the tariff mechanism includes a component of efficiency improvement that must be imposed on the operator and on which the authority has some discretionary power, at least above some thresholds. The planning activity is illustrated in a (public) programming document, the OTA *plan* ("piano d'ambito").

The *control* involves the quality of service in general and the amount of investment actually carried-out by the controlled firm.

With the recent abolishment of the OTAAs, Italian regions have to reorganize the sector, and must, among other things, decide how to re-attribute the above illustrated tasks.

3.3 The efficiency of regulation authorities.

Many regulatory schemes, especially those developed during the recent years, are aimed to improve the efficiency of the firms operating the regulated service. The reason is that, in a regulated context, higher efficiency implies lower prices for consumers. However, regulation is not costless: public authorities are resource-consuming entities, and their cost will, sooner or later, burden the consumers, through the tax system or also through the tariff mechanism, as it is the case for Italian OTAAs. Therefore, in a social welfare perspective, it is worthwhile to consider also the cost and the efficiency of regulatory bodies. The Italian system, with the peculiarity of being highly fragmented, provides an interesting starting point as it allows a benchmarking analysis.

The efficiency of independent regulatory bodies is not a debated issue in the literature. However, there exist a current of works in efficiency analysis related to the performance of local authorities and local government, whose contributions are helpful to address some of the issues which are a concern in this work as well, such as the identification of input and output variables. Many studies employ monetary input measures; moreover some of them point out that it is difficult to individuate output indicators able to express a "production" concept quite different from the traditional meaning, and that it is necessary to identify suitable proxies to capture the main activity of the entity. Very often these studies provide a second stage analysis aimed to identify the drivers of the detected inefficiency. See, among the others, De Borger and Kerstens (1996a, 1996b), about Belgian local governments; Worthington and Dollery (2000), on Australian councils; Da Conceição Sampaio De Sousa and Stošić (2005), on Brazilian municipalities; Prieto and Zofío (2001), which include also effectiveness measures, Giménez and Prior (2007), which distinguish a short-term and long term inefficiency, and Balaguer-Coll et al. (2007), on Spanish municipalities.

Moreover, another current of interest is that one focused on the evaluation of regulatory agencies performance. Such evaluations, in general, do not involve efficiency (at least, not in the same sense as in efficiency analysis). Rather they are aimed to benchmark regulators by means of indicators of presence and intensity of some desirable characteristics. Independence is by far the most mentioned one. It assumes several meanings: it is either independence from political entities or from other stakeholders, including the controlled firm. In particular, independence from government is important because sometimes the latter (this is especially true in the network industry) is also owner, or co-owner, of the controlled firms. This also applies to Italian water suppliers, at local level. Moreover, independence means also "specialization" of the authority, and probably a broader knowledge of the industry and of the technology, allowing to reduce the problem of asymmetric information between regulator and controlled firms.

Other characteristics considered in performance indicator are, for instance, transparency in the disclosure and publication of relevant information, and accountability, involving all the mechanisms aimed to ensure the control of authorities' budgets and performance by the community. For some examples of such evaluations, see, among the others, Johannsen (2003), Andres et al. (2007), Gilardi and Maggetti (2010), Gilardi, 2002.

3.4 B&W's framework to evaluate mergers.

In a context of the reorganization of the water sector, and given the recent political purposes towards an aggregation of local public authorities, an evaluation of the convenience of merging Italian OTAAs as a way of restructuring the system seems to be of crucial interest. Such an analysis is developed in this work following the methodology presented in Bogetoft and Wang (2005), whose notation is maintained, and more broadly illustrated in Bogetoft and Otto (2011).

This method has two important advantages: first, it is based on efficiency evaluation, thus allowing to answer the question related to water authorities efficiency (Q1). Second it provides an *ex-ante* measure of potential gains, based on the observed technology, and it is then suitable to evaluate mergers before they are realized, that is actually the aim of this work.

Let us assume to have a sample of I units (or firms), each one using a vector of inputs x to produce a vector of outputs y. Suppose now that we wish to merge a subset J of the I units. By directly pooling inputs and outputs, we will obtain a merged unit (DMU^J) that uses $\sum_{j\epsilon J} x^j$, i.e. the sum of the inputs of the starting units, to produce $\sum_{j\epsilon J} y^j$ (the sum of the outputs). We can wonder whether or not such a production plan is efficient, compared to the technology T (the production possibility set) as defined by the original I observations. If some inefficiency is detected, it will be interpreted as a potential gains from the merger: after having aggregated the J units, the technology still allows some efficiency improvements. Therefore, the *overall potential gain from the merger*, in an input-oriented perspective, is defined as

$$E^J = Min \left\{ E\epsilon R_+ \middle| \left(E\left[\sum_{j\epsilon J} x^j\right], \sum_{j\epsilon J} y^j \right) \epsilon\, T \right\}$$

i.e., it is the maximal radial contraction of the aggregated inputs that allows to produce the aggregated outputs. If E^J<1 the merger is potentially advantageous, if E^J>1, instead, it leads to potential losses.

What is particularly interesting in this methodology is that, on top of allowing to quantify the gain (or loss) from a merger, it also suggests a decomposition.

First of all, the inefficiency (or, in our perspective, the potential) of DMU^J can derive from the individual technical inefficiency level of the starting units, which can be recovered even without an extraordinary operation, and therefore it is not a direct effect of the merger. In order to get rid of this effect it is necessary to compute the *adjusted overall gain from the merger*:

$$E^{*J} = Min \left\{ E \epsilon R_+ \middle| \left(E \left[\sum_{j \epsilon J} E^j x^j \right], \sum_{j \epsilon J} y^j \right) \epsilon\, T \right\}$$

where E^j is the individual efficiency score of each firm $j \epsilon J$. E^{*J} is the maximal proportional reduction in the aggregated inputs that allows to produce the aggregated outputs once we have net out the individual inefficiency of the starting units. In fact, they are not involved in the merger as they are; rather, we consider their projections on the frontier.

The ratio

$$T^J = \frac{E^J}{E^{*J}}$$

is the *technical efficiency index* (*"learning"* in Bogetoft and Otto, 2011); it indicates what can be saved if the starting units individually adjust to best practices. Clearly, $T^J \epsilon\, [0,1]$.

A second effect is related to the fact that a merger leads in general to a different input and output mix, which can be more "powerful", or more productive. This is a sort of *scope* effect (even if it differs from the traditional definition of economies of scope as it involves also a re-mix on the input side) and it is measured by the *harmony index*

$$H^J = Min\left\{H\epsilon R_+ \middle| \left(H\left[|J|^{-1}\sum_{j\epsilon J} E^j x^j\right], |J|^{-1}\sum_{j\epsilon J} y^j\right) \epsilon\, T\right\}$$

where $|J|$ is the number of units that we want to merge. H^J is thus defined as the maximal proportional contraction in the average inputs that allows to produce the average outputs, starting from the original units as they were efficient. By doing so, we can quantify the potential improvement that derive from a new input and output mix. In fact, we are evaluating a virtual firm that produces outputs and uses inputs with the same proportions of DMU^J. Anyway, by taking the average, this virtual firm operates at a scale that is about the same of the starting units, therefore the size effect is not coming into play (however, the authors highlight that this is true if the size of the merged units is similar; if, instead, they differ substantially in their size, H^J is likely to include also some size effect). If we find H < 1 harmony gains are available, while H >1 indicates harmony losses.

The impact of size is measured by a third indicator, the *size index,* defined as

$$S^J = Min\left\{S\epsilon R_+ \middle| \left(S\left[H^J \sum_{j\epsilon J} E^j x^j\right], \sum_{j\epsilon J} y^j\right) \epsilon\, T\right\}$$

that expresses what can still be saved by means of the merger, in terms of input proportional reduction, by operating at full rather than average scale. S<1 indicates size gains, while S>1 indicates size losses.

The size and the harmony indexes are the components of the measure we have called *overall adjusted potential gain*, i.e.

E^{*J} =$H^J * S^J$

Therefore, we get what the authors call the *basic decomposition*

$$E^J = T^J * E^{*J} = T^J * H^J * S^J$$

It shows that the overall gain from merger depends on three main components.

- The *technical efficiency or learning* component, which has to be isolated because it can be corrected for also without recurring to an extraordinary operation such as a merger. As the authors point out, if the low technical efficiency is due to causes such as the scarce motivation of the managerial team, mechanisms such as yardstick competition can solve the problem, providing incentive to the inefficient units to imitate best practices. On the other hand, if the cause is the lack of management talent, a merger can be a solution as it would involve a radical change in the control activities and in the composition of the managerial team.
- In principle, a genuine merger could not be necessary also to achieve the potential *harmony* gains: in order to get more productive input and output combinations it is also possible to think about reallocating the resources and the products by means of market transaction. However, as it would be clarified in the next sections, in the framework of this work such a solution is not possible. Harmony gains can derive just from the remix of outputs (as we will operate with a unique input, cost), and outputs are strictly linked with the area Authorities operate on, therefore they cannot be traded. Harmony gains, if any, could be achieved only by a real merger.
- Finally, about the *size* effect, the authors say that there is no substitute for a merger in case of low S^J measure: size potentials can be exploited only through larger entities.

B&W method has been applied in several works, either published or not. See for instance Simper and Weyman-Jones (2008), about police services, who, differently from what illustrated here, adopt an output oriented perspective; output orientation is also used in Goulay et al. (2006), working on banks mergers in India; turning to input oriented approaches, it is important to mention examples such as Bagdadioglu et al. (2007), on Turkish electric distribution companies; Walter and Cullmann (2008) for a bootstrapped application to local public transport in Germany; Blancard et al. (2009), on French farms, who employ a directional distance function approach under the assumption of non-convex technology, thus allowing for gains from specialization. All these contributions employ non-parametric approaches. Moreover B&W methodology has been used in several studies commissioned by regulatory and government agencies (see Bogetoft and Otto, 2011), in either parametric and non-parametric framework.

3.5 Estimation procedures.

B&W method can be implemented with whatever kind of efficiency technique, either parametric or non-parametric. In this work, a preliminary DEA-based model is performed, including a single input (cost) and multiple outputs. Input orientation is chosen because the output measures are mainly territory-linked, therefore they are not under OTAAs control, while cost is. Subsequently, given some drawbacks of this approach, a complementary estimation based on cost frontier is run. The results of the two models will be reported and compared.

3.5.1 DEA-based approach.

Following the illustrative application reported in B&W (2005), a first estimation based on data envelopment analysis is performed. We assume variable returns to scale, to avoid to impose a predetermined sign on the size effect (S^J), which is expected to be the dominant one. In fact, by assuming, for instance, constant return to scale, we would constrain S^J to be equal to one; under an IRS (increasing returns) technology, we would always find S^J< 1.

The DEA approach involves the following steps.

1) Run a standard DEA problem a first time, in order to get the efficiency scores for each one of the originally observed units (OTAAs). Moreover, this step provides the sign of the returns to scale (increasing or decreasing) under which each unit is operating.
2) Simulate the mergers. In this work, they are planned following two criteria: geographical proximity and size of the starting units. It means that we simulate mergers between contiguous units (mainly, but not always, belonging to the same region), and starting from "small" ones (those ones operating under IRS), which would get the larger size benefit from aggregation. It is worthwhile to notice that some of the starting units are involved in several mergers, which are, therefore, mutually exclusive. In fact, this work is not aimed to suggest a way to aggregate OTAAs; rather, we want verify whether or not merging authority is a valuable policy option. The total number of simulated mergers is 21.
3) For each simulated mergers three virtual observations are constructed. One is created by pooling the observed input (cost) and the observed outputs, and is used to determine the overall gain E^J. The second includes the same output values as the first one, but the cost value is the sum of the target costs of the starting units (each OTAA's cost is multiplied by its efficiency score), i.e. we aggregate the original units as they were efficient. This virtual

observation is necessary to get an estimate of E^{*J}, the adjusted overall gain. Finally, the third virtual observation is created by dividing the input and output values of the second one by the number of firms involved in the merger. Therefore, it is a unit that uses the average (efficient) level of input to produce the average level of output, and it is employed to compute the harmony index, H^J.

4) Run a super-efficiency DEA program including the constructed virtual observations one-by-one. In this way we will compare each one of them with a frontier constructed with the starting units only. The obtained efficiency scores are the E^J, E^{*J} and H^J measures. T^J will be computed by using the ratio illustrated above, and S^J is computed residually, as $S^J = \frac{E^{*J}}{H^J}$.

Such an approach has some potential drawbacks, clearly illustrated in Bogetoft and Otto (2011). First, a relevant problem of DEA super-efficiency estimates, when VRS are assumed, is that sometimes the optimization problem has no solution. It happens, in an input-oriented perspective, every time that the value of one of the outputs of the unit under evaluation exceeds the maximum value that variable assumes over the remaining observations. This is often the case in evaluating mergers, as they are constructed by summing the variables of the starting units, and implies that the indexes of interest cannot be computed.

Second, having few observations for certain levels of output leads to "imprecise" estimates of that part of the frontier, leading to "strange" or unreliable efficiency scores. It happens in our sample for large levels of outputs, i.e. involving the part of the frontier mergers are compared with.

Third, in the DEA framework the production possibility set is assumed to be convex. It implies that any convex combination of the existing (feasible by assumption) units is feasible as well, meaning that the harmony index (based on "average" virtual observations) is constrained to be less than one (always positive harmony effect).

The need to overcome these problems is the reason because we adopt a parallel parametric approach.

3.5.2 Cost frontier approach

A cost frontier represents an interesting parametric alternative to the DEA approach. The translog functional form is suitable in this case because it is a flexible one, and allows for either increasing or decreasing returns to scale and positive or negative mix effect. Moreover, the stochastic frontier approach allows to separate the inefficiency from the noise term.

Note that the same framework as in the DEA approach is maintained: we will work again with multiple outputs and a single input. Therefore, unlike in the traditional cost functions, no input price is included as an explanatory variable. We will anyway refer to ours as a cost function, but it can also be thought as an input distance function (or input requirement function) with a unique input. (See Bogetoft and Otto for examples of similar definitions of “cost function”; see also De Borger and Kersten, 1996a).

Also in this case, the best way to illustrate the procedure is to explain it step-by-step.

1) Estimate the translog frontier cost function as

$$\ln C = \alpha + \sum_{i}^{n} \beta_i lnY_i + \sum_{i}^{n} \frac{1}{2}\delta_i lnY_i^2 \sum_{j(j\neq i)}^{n} \sum_{i}^{n} \gamma_{ij} lnY_i lnY_j + u + v$$

   Where the Y_i indicate the outputs, v is the symmetric (normally distributed) noise term and u is the inefficiency term, always positive, assumed to follow an half-normal distribution.

2) Create the output variables, the quadratic and the interaction terms for the simulated mergers (the same hypothetical mergers considered in the parametric application are maintained), by pooling the values of the observed starting units. Moreover, in order to be able to compute the harmony index, also the average-value variables and the related second order terms are created for each merger.

3) For each merger, the efficiency indicators are computed as in Bogetoft and Otto (2011); these definitions are completely equivalent to those described in section 4.

$$E^J = c(\sum_{j\epsilon J} y^j) \Big/ \sum_{j\epsilon J} x^j$$

$$E^{*J} = c(\sum_{j\epsilon J} y^j) \Big/ \sum_{j\epsilon J} c(y^j)$$

$$T^J = \sum_{j\epsilon J} c(y^j) \Big/ \sum_{j\epsilon J} x^j$$

$$H^J = c(\frac{1}{|J|}\sum_{j\epsilon J} y^j) \Big/ \frac{1}{|J|}\sum_{j\epsilon J} c(y^j)$$

$$S^J = c(\sum_{j\epsilon J} y^j) \Big/ (|J| c(\frac{1}{|J|}\sum_{j\epsilon J} y^j))$$

Where:

- $c(\sum_{j\epsilon J} y^j)$ is the predicted (efficient) cost associated to the output vector of the merged unit;
- $\sum_{j\epsilon J} x^j$ represents the pooled observed costs of the starting units. Note that, as we do not want the random noise component to play a role in determining the overall gains and the technical efficiency effects, the observed individual cost is corrected by eliminating the noise as estimated through the cost frontier;
- $\sum_{j\epsilon J} c(y^j)$ indicates the sum of the (efficient) fitted costs of the starting units;
- $c(\frac{1}{|J|}\sum_{j\epsilon J} y^j)$ defines the minimal cost of the average output vector of a given merger;
- $\frac{1}{|J|}\sum_{j\epsilon J} c(y^j)$ is, instead, the average minimal cost of producing the output vectors of the units involved in the merger;
- $|J| c(\frac{1}{|J|}\sum_{j\epsilon J} y^j)$, defines the re-scaled minimal cost of the average unit, i.e. the cost corrected for the re-mix effect, but still not including the size impact.

3.6 Data and variables

The dataset contains operational and cost data on 50 over 92 Italian OTAAs, with observations ranging from 2001 to 2008. The main source are the annual reports of CONVIRI (Italian national commission for water resource), integrated with information found on the OTAAs websites, especially on the OTA plans, or directly provided by the Authorities.

The dataset does not cover the whole country for two main reasons:

- not all the OTAAs communicate their cost information to CONVIRI and
- not in every Area the activity of the provider had already started in 2008, implying that some Autorities did not perform the control activity, and so they are not comparable with the rest of the sample.

Even if the dataset is configured as an unbalanced panel, here we wish to apply a methodology created for cross-sectional analyses. Therefore the cost values (the only time-variant variable) are averaged over the available years and the mean value is used as input. This operation has also the advantage to cope with the problem of the application of the "cash principle" in Italian public accountancy, i.e. a cost is attributed to the year in which the payment is made and does not reflect the effective resource consumption, which is more likely to be represented by working with the average annual cost.

The average operational cost of the authority is the unique input in the analysis.

On the output side, three variables are employed, which are aimed to proxy the main OTAAs activities.

- OTAs surface (SUP). It is a strictly "quantitative" measure (capturing a sort of "volume" of the activity), as it expresses the physical dimension of the area. It is employed as a proxy of planning and control tasks, in the sense that a larger territory to be explored (to plan the investments) and monitored (in the control phase) is likely to positively affect cost.
- Number of municipalities with more than 20 thousands inhabitants (COM_20000). It can be thought as well as a "volume" variable. In fact, authorities have to deal with a number of institutional relations, mainly with the municipalities constituting the OTAs. It is reasonable to think, however, that not all the municipalities absorb the same authorities effort: probably the most time and resource-consuming relations involve the largest ones. For this reason only the presence of "large" municipality is included as an output.
- the average annual amount of investment actually realized by the operating firm (IMREAL). It is computed as the total amount of investment realized up to 2008 divided by the number of years of activity of the firm (after Galli's Act implementation). In principles, it can be interpreted as the product of two components:

IMREAL = average annual investment planned by the authority X realization rate.

The first factor is another measure of volume, as it depends on the dimension and on the population of the area; moreover, it reflects the initial state of the infrastructure.

The realization rate, instead, is a measure of the "effectiveness", or the quality, of OTAAs activity, because it expresses the goodness of OTAAs control and incentives. Taken as a whole, IMREAL also proxy the long-term mission of the Authorities: the quantity and quality of water available for future generations depends on the present ability to preserve the resource, that in turns is linked to the state of the water supply and treatment infrastructure. It can also be considered as a proxy of the quality of service. In fact, in absence of sufficient information on direct quality indicator (such as, for instance, the quantity of wastewater actually treated or the amount of network losses), it can be considered as a proxy of the OTAA's effort towards the achievement of the necessary qualitative standards.

Therefore, to give an overall interpretation of the structure of the output, we can say that the amount of work required to an OTAA is "large" when the territory is large, or when it is necessary to deal with many large towns (or cities), or when the initial state of the infrastructure is poor. Moreover, the work is "well done" if the authority is able to provide the correct incentive to invest, leading the controlled firm to provide a service sufficiently good.

Table 3.1 provides some descriptive statistics.

Table 3.1 Summary statistics.

VARIABLES	MEAN	ST_DEV	MIN	MAX
Cost (€/000)	631	465.85	135.75	2429.79
SUP (km2)	3633.7	4116.20	162	24090
COM_20000 (no.)	5.84	8.04	1	49
IMREAL (€ millions)	17.29	16.06	0.11	60.28

3.7 Results

Before analyzing the efficiency levels of OTAAs and the potential gains from mergers, let us have a look to the frontier cost function estimates, reported in table 3.2

The estimated parameters are quite satisfactory. All the first order output coefficients have the expected positive sign; two of them are also highly significant, while the third one (COM_20000) is not. However the second order coefficient related to the same variable shows a p-value of 0.066, thus supporting the choice of having included such an output. Moreover, and perhaps more interestingly, also the interaction of COM_20000 with SUP is also highly significant and negative, suggesting the existence of some synergies between the two outputs. Intuitively, it seems reasonable that, when the surface is larger, an higher number of large municipalities (i.e. less dispersed inhabitants) negatively affects marginal cost, for instance because it makes the monitoring activity easier.

Table 3.2 Frontier cost function estimates.

variable	coefficient	p-value
SUP	0.4450792	0.000
IMREAL	0.2518785	0.002
COM_20000	0.0559987	0.544
SUP x IMREAL	0.0434174	0.782
SUP x COM_20000	-0.3403789	0.003
IMREAL x COM_20000	-0.0317096	0.689
SUP^2	0.2713472	0.037
IMREAL^2	0.1007901	0.065
COM_20000^2	0.2780884	0.066
constant	-0.5192467	0.000
	coefficient	st_error
sigma v	0.2806548	0.0647871
sigma u	0.4267856	0.1338082
sigma2	0 .260913	0.0920484
lambda	1.520678	0.1854859

Finally, the sigma and the lambda values indicate that a large proportion of variability in the residuals is explained by the inefficiency term, therefore it is correct to employ a frontier cost function.

3.7.1 OTAAs' efficiency.

This subsection is aimed to provide an answer to Q1, as will analyze the efficiency level at which OTAAs operate. Table 3.3 reports a summary of the (Farrell) efficiency scores as determined by means of the DEA and the parametric approaches, respectively.

Table 3.3 Summary of the estimated efficiency scores

	mean	st_dev	min	max
DEA efficiency scores	0.62	0.24	0.11	1
SFA efficiency scores	0.71	0.12	0.27	0.90
Spearman rho	0.73			

The two models provide quite consistent results. A relevant level of inefficiency emerges, which is about 38% in the DEA model and about 30% in the stochastic frontier model. Moreover, high variability among the efficiency scores emerges, more relevant for the non-parametric estimates. Finally it is worthwhile to mention that the Spearman correlation coefficient is relatively high, meaning that the two models rank the units in similar ways.

3.7.2 Potential gains from merging OTAAs.

Now, let us address the problem highlighted in Q2, i.e. whether or not merging Italian water authorities leads to cost advantages, and therefore is a suitable way of reorganizing the sector. Table 3.4 presents the estimated potentials of the simulated mergers. Among them, the mergers identified as 1 and 2 had really been planned, before OTAAs' abolition. Mergers 17 and 18 are particular ones because they cross regional boundaries. Finally, 16 and 21 simulate "regional" authorities.

Table 3.4 Potential gains from mergers.

MERGER	E^J		E^{*J}		T^J		H^J		S^J	
	DEA	SFA	DEA	SFA	DEA	SFA	DEA	SFA	DEA	SFA
1	NS	0,59	NS	0,80	NS	0,73	0,97	0,96	NS	0,83
2	0,51	0,61	0,81	0,91	0,63	0,68	0,87	1,02	0,93	0,89
3	0,63	0,65	0,86	0,85	0,73	0,77	0,92	0,95	0,93	0,90
4	NS	0,64	NS	0,89	NS	0,72	1,00	0,97	NS	0,92
5	0,46	0,44	0,84	0,57	0,55	0,76	1,00	0,88	0,84	0,65
6	0,43	0,46	0,90	0,67	0,49	0,70	0,89	0,93	1,01	0,72
7	0,31	0,49	1,05	0,85	0,29	0,57	1,00	0,99	1,05	0,86
8	NS	0,63	NS	0,88	NS	0,72	1,00	1,00	NS	0,88
9	0,67	0,67	1,02	0,88	0,66	0,76	1,00	1,00	1,02	0,88
10	0,61	0,67	0,89	0,88	0,69	0,76	0,99	1,00	0,90	0,89
11	0,61	0,68	1,03	0,85	0,60	0,79	0,98	1,00	1,05	0,85
12	0,37	0,55	0,91	0,85	0,41	0,64	0,92	1,01	1,00	0,84
13	NS	0,71	NS	0,88	NS	0,81	0,98	1,01	NS	0,88
14	0,50	0,62	1,08	0,84	0,46	0,74	0,96	0,97	1,12	0,87
15	NS	0,56	NS	0,84	NS	0,67	0,91	0,97	NS	0,86
16	0,41	0,49	1,10	0,78	0,37	0,63	0,94	1,01	1,17	0,77
17	0,65	0,66	1,03	0,87	0,63	0,76	0,98	1,01	1,06	0,87
18	NS	0,64	NS	0,89	NS	0,71	0,98	1,01	NS	0,88
19	NS	0,56	NS	0,90	NS	0,63	0,98	1,00	NS	0,90
20	NS	0,55	NS	0,89	NS	0,62	1,00	0,99	NS	0,90
21	NS	0,46	NS	0,65	NS	0,71	0,96	0,95	NS	0,69
MEAN	0,5144	0,5876	0,9597	0,8312	0,5424	0,7075	0,963	0,9822	1,0066	0,84455

First of all, it emerges that, by employing DEA with the assumption of VRS, many among the simulated mergers generate super-efficiency programs with no solution, which is one of the disadvantages leading us to prefer the parametric approach.

As it results from the table, both the models (when a solution exists, for the DEA based one), show always positive and important potential overall gains (E^J always smaller than one, on average indicating gains above 40%). Anyway, once the individual technical inefficiency is cleaned for, the potential is relevantly reduced, with some cases of losses within the DEA results. The reason for that lies in the technical efficiency effect, T^J, that is large in both the models (as expected, given the low efficiency levels of the starting units).

Between the two components of E^{*J}, H^J does not play a relevant role: in both the approaches it is usually very close to 1 (in the SFA model, where it is not constrained to lie below the unit, there are also cases where weak harmony losses are detected). It is not surprising, since none of the starting units was "specialized" in some of the outputs: all the OTAAs "produce" all the output measures, therefore potential gains or losses from remixing already quite balanced output vectors are very limited. Moreover, it is worthwhile to point out that the harmony effect relevance is somehow limited from a policy perspective. We mean that the "ideal" authority should not pursue the objective of operating with the most productive output mix. In fact, the level of each output is defined by the physical (SUP) and demographical (COM_20000) characteristics of the OTA, by the initial state of the infrastructure, which can be thought as "given" in a certain territory, and by the qualitative standards of service which should be defined on the basis of citizens needs and preferences. In other words, if it seems meaningful for OTAAs to pursue the "optimal size" in terms of cost savings, it makes less sense to reason in terms of "optimal output mix", because the choices in this sense are (and must be) more directed to achieve targets which are not cost-based.

What really differs among the two models is the size effect, that also causes the differences in the computed E^{*J}. In fact, the DEA based S^J shows on average no gains coming from larger size (the average of the indicators is almost 1), and there are many cases showing size losses. This is so even if the mergers have been created starting from the smallest units, in order to maximize the size potential; this would suggest that the technology shows diseconomies of scale. However, as already mentioned in section 5, in Bogetoft and Otto (2011), the authors point out that such a result is likely to occur when the frontier is constructed with few observation for large levels of output, which is actually this case. In fact, DEA estimates are generally biased, because the

methodology generates an "optimistic" inner approximation of the technology, as it is constructed following the minimal extrapolation principle. This means that it leads to estimate efficiency scores higher than the "true" ones, that in this context is equivalent to detect lower potential. The bias is larger in the part of the production possibility set where the observation are more sparse.
This is the reason because we trust more SFA based S^J estimates, which conclusions differ relevantly from DEA ones. In fact, what emerges in this case is a relevant positive potential due to enlarged size. It is shown to be larger the smaller are the starting units involved in the merger (this is the case of merger 5, 6, 16). Moreover, it is also positively affected by the number of the involved units (merger 1 and 21). This finding is quite reasonable: in a technology showing economies of scale, the most advantageous choice is to merge the smallest "firms", which operate under the most unfavorable conditions; the advantage is larger if the merged units are many. The always positive size effect is the driver of the overall adjusted potential gain measures, that are also always positive within the SFA model.
Summing up, from the application of B&W methodology it emerges that Italian OTAAs are likely to benefit from an aggregation policy. First of all, it may be useful to recover some of the technical inefficiency of the starting units, which is relevant, even if in principle other tools are available to solve such a problem (e.g. benchmarking methods). A re-mix of the outputs, instead, would not have important effects, probably because the OTAAs already operate with balanced output combinations at individual level. The size indicators are probably the most interesting: the preferred model show average potential savings around 15%, with higher values when the merger involves very small or many units (more than 3). Due to the size effect, also the overall adjusted gain indicators are always positive, meaning, roughly speaking, that merging OTAAs is always advantageous, at least over the group of mergers we have simulated here.

3.8 Conclusions

The purpose of this work is twofold: to evaluate the efficiency level of Italian OTAAs (water regulation authorities), and to test whether some potential cost advantages would be available if the existing OTAAs were merged. These are relevant questions in a perspective of sector reorganization, that will occur given the recent OTAAs legal abolition.
We employ the methodology suggested in Bogetoft and Wang (2005) to evaluate the potential gains from mergers, which is based on efficiency analysis, and the method is implemented in a

DEA- and an SFA-based models, respectively. Both the models show the presence of relevant individual inefficiency of the observed authorities, but they provide inconsistent answer in detecting the mergers' potential. Given some drawbacks of the DEA-based approach, we rely on the findings of the parametric model. They show always positive potential (i.e. gains) for the simulated mergers, which is mainly driven by the size effect, meaning that the merged units are likely to benefit from relevant economies of scale. Almost no effect (either positive or negative) comes from re-mixing the outputs, probably because the starting units already operate with balanced production combinations. Finally, relevant gains are available by recovering the technical inefficiency of the starting units.

From a policy perspective, such results suggest that integration is a possibility that must be considered by Italian Regions in reorganizing the sector, if they will adopt the option of maintaining independent authorities as regulators in the water industry. As emerges from the discussed literature, the latter is a relevant option, because independency is broadly recognized as a desirable characteristic of regulatory bodies. Moreover, some incentive mechanism should be provided in order to improve authorities' operational efficiency.

GENERAL CONCLUSIONS

This work is composed of three chapters treating the integration issue in public utilities.

The first chapter is 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 does 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). 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 work 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 important point to be considered in future research.

The second chapter presents an empirical analysis of the economies of vertical integration in fixed telecommunications, which is an issue of large interest but rarely addressed from the empirical perspective, as highlighted in chapter 1. The dataset includes European incumbent firms and the analysis employs a method based on Data Envelopment Analysis. It allows to compute the economies of vertical integration by comparing, for each firm, the efficiency scores obtained with respect to the separated firms frontier with the efficiency scores computed with respect to the integrated firms frontier. The results results show that diseconomies of vertical integration are relevant, providing an important argument in favor of separation policies. However, they reduce when the downstream output (retail lines) is split in narrow and broadband lines (i.e., by considering the quality of the downstream accesses), for firms more concentrated on broadband.

The third chapter is a quite particular one, as it is not focused on firms but on regulatory agencies. It is aimed to measure the potential gains from merging Italian water authorities. The dataset contains operational and financial (cost) information on fifty agencies (more than half of the existing authorities).

The approach, illustrated in Bogetoft and Wang (2005) and in Bogetoft and Otto (2011), is implemented both in a parametric and in a non-parametric framework. It is particularly interesting as it allows to compute the gains ex-ante, i.e. before the merger, on the basis of the technology as it is defined by the existing observations. Moreover, the computed potential gain (or loss) can be decomposed in technical efficiency component, harmony and size effect. By looking at the results it emerges a relevant potential from recovering technical inefficiency (which in principle could be corrected for directly at the starting units level). Moreover, important gains seem to be achievable in terms of size effect, while the output remix (harmony) effect is limited.

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

Andres, L., Guasch, J.L., Diop, M., Lopez Azumendi, S. (2007). "Assessing the Governance of Electricity Regulatory Agencies in the Latin American and Caribbean Region: A Benchmarking Analysis". *The World Bank Latin America and the Caribbean Region Sustainable Development Department.* Ploicy research working paper no. 4380.

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.

Bagdadioglu, N., Waddams Price, C., Weyman-Jones, T., (2007). "Measuring potential gains from mergers among electricity distribution companies in Turkey using a non-parametrci model". *The energy journal,* 28(2), pp. 83-110.

Balaguer-Coll, M.T., Prior, D., Tortosa-Ausina, E. (2007). "On the determinants of local government performance: a two-stage nonparametric approach". *European economic review,* 51, pp. 425-451.

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.

Blancard, S., Boussemart, J.-P., Leleu, H.(2009). “Measuring potential gains from specialization under non-convex technologies”. *LEM – Lille Economie & Management.* Document de travail no. 2009-04.
Online at http://lem.cnrs.fr/Portals/2/actus/DP_200904.pdf

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.

Bogetoft, P., Otto, L. (2011). “Benchmarking with DEA, SFA, and R”. *International series in operational research and management science. Springer.*

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”. *Management Science,* vol. 34, n.1, pp. 1-26

Crandall, R.W., Eisenach, J.A., Litan, R.E. (2010). “Vertical separation of telecommunication networks: evidence from five countries”. *Federal Communication law journal,* vol.62, n.3, pp. 493-539

Cummins, J.D., Weiss, M.A., Zi, H. (2003). “Economies of scope in financial services: A DEA bootstrapping Analysis of the US insurance industry”. Available at http://irm.wharton.upenn.edu/F03-Cummins.pdf

Da Conceição Sampaio De Sousa, M., Stošić, B. (2005). “Technical efficiency of the Brazilian municipalities: correcting nonparametric frontier measurement for outliers”. *Journal of productivity analysis,* 24, pp. 157-181

De Borger, B., Kerstens, K. (1996a). “Cost efficiency of Belgian local governments: a comparative analysis of FDH, DEA and econometric approaches”. *Regional science and urban economics,* vol. 26, pp. 145-170.

De Borger, B., Kerstens, K. (1996b). “Radial and nonradial measures of technical efficiency: an empirical illustration for Belgian local governments using an FDH reference technology”. *Journal of productivity analysis,* vol. 7, pp. 41-62.

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.

Färe, R. (1986). “Addition and efficiency”. *Quarterly journal of economics,* 51, pp. 861-865.

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

Ferrier, G.D., Grosskopf, S., Hayes, K.J., Yaisawarng, S. (1993). “Economies of diversification in the banking industry”. *Journal of monetary economics,* 31, pp. 229-249.

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.

Fried, H.O., Schmidt, S.S., Yaisawarng, S. (1998). "Productive, scale and scope efficiencies in U.S. hospital-based nursing homes". *INFOR,* 36, 3. pp. 103-119.

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.

Gilardi, F. (2002). "Policy credibility and delegation to independent regulatory agencies: a comparative empirical analysis". *Journal of European public policy*, vol.9, no.6, pp. 873-893.

Gilardi, F., Maggetti, M. (2010) "The independence of regulatory authorities"
Online at http://www.fabriziogilardi.org/resources/papers/gilardi_maggetti_handbook.pdf

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.

Gimenez, V.M., Prior, D. (2007). “Long- and short-term cost efficiency frontier evaluation: evidence from Spanish local governments”. *Fiscal studies*, vol.28, no.1, pp. 121-139.

Gourlay, A., Ravishankar, G., Weyman-Jones, T. (2006). “Non-parametric analysis of efficiency gains from bank mergers in India”. *Loughborough University, discussion paper series,* wp. 2006-17.
Online at
http://www.lboro.ac.uk/departments/sbe/RePEc/lbo/lbowps/Gourlay_Ravishankar_Weyman_Jones_Indian_Banks.pdf

Grosskopf, S., Yaisawarng, S. (1990). Economies of scope in the provision of local public services. *National tax journal,* 43, 1, pp. 61-74

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.

Johannsen, K.S. (2003). "Regulatory independence in theory and practice – a survey of independent energy regulators in eight European Countries". *AKF Forlaget*
Online at www.akf.dk/udgivelser/2003/pdf/**regulatory_independence**.pdf

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.

Kittelsen, S.AC., Magnussen, J. (2003). "Economies of scope in Norwegian hospital production – a DEA analysis". Available at:
http://www.med.uio.no/helsam/forskning/nettverk/hero/publikasjoner/skriftserie/2003/HERO2003_8.pdf

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

Kwon, O.S., Yun, W.C. (2003). "Measuring economies of scope for cogeneration systems in Korea, a non-parametric approach. *Energy economics,* 25, pp. 331-338

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

Nucciarelli, A., Sadowski, B.M. (2010). "The Italian way to functional separation: an assessment of background and criticalities". *Telecommunications policy,* vol.34, 7, pp. 384-391.

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.

Prieto, A.M., Zofío, J.L. (2001). “Evaluating effectiveness in public provision of infrastructure and equipment: the case of Spanish municipalities.” *Journal of productivity analysis,* 15, pp. 41-58.

Prior, D. (1996). “Technical efficiency and scope economies in hospitals”. *Applied economics*, 78, pp. 1295 - 1301

Prior, D., Solà M. (2000). “Technical efficiency and economies of diversification in health care”. *Health care management science,* 3, pp. 299-307.

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

Simper, R., Weyman-Jones, T. (2008). “Evaluating gains from mergers in a non-parametric public good model of police services”.*Annals of public and cooperative economics,* 79, 1, pp. 3-33

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

Teppayayon, O., Bohlin, E. (2010). “Functional separation in Swedish broadband market: next step of improving competition”. *Telecommunication Policy,* vol. 34, 7, pp. 375-383.

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.

Walter, M., Cullmann, A. (2008). “Potential gains from mergers in local public transport – an efficiency analysis applied to Germany”. *Deutsches Institut für Wirtschaftsforschung,* discussion paper.
Online at http://www.diw.de/documents/publikationen/73/diw_01.c.89947.de/dp832.pdf

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

Worthington, A.C., Dollery, B.E. (2000). “Measuring efficiency in local governments’ planning and regulatory function”. *Public productivity and management review,* vol.23, no.4, pp. 469-485.