COSTS, TECHNOLOGY AND OWNERSHIP FORM OF NATURAL GAS DISTRIBUTION IN ITALY

Giovanni Fraquelli
Ceris-CNR, University of Turin

Roberto Giandrone
Italgas S.p.A.

Abstract

The analysis of the technology and costs of the gas distribution networks highlights that the number of customers is more important than the amount of gas delivered, as well as the absence of economies of scale, the presence of economies of density and the significant role of the morphologic and demographic variables. The diversification towards other services, such as water and electricity, provides good opportunities for efficiency. The lower costs for private operators and the constant economies of scale indicate that the privatisation process should continue and confirm the benefits of having many operators (*yardstick competition*). The control of monopoly rents in efficient conditions requires the use of a tariff system similar to a *price-cap*, provided that it takes into account the territorial constraints.

Jel Classification: L33; L95

Key words: Gas utilities, Costs, Public and private enterprise

The contents of this work are the result of our own analyses and evaluations and are independent of the views of Italgas S.p.A.

We are grateful for the comments to Carla Marchese and Davide Vannoni. We also acknowledge the assistence of Silvana Zelli and Maria Zittino of Ceris-CNR in helping us to collect data for the paper.

Paper presented at the 24th Annual Conference of the European Association for Research in Industrial Economics, August 31-September 3, 1997, Leuven, Belgium

1. Introduction

Local gas distribution to families and firms is a service industry that transfers fuel from the large national transportation networks to the residences of the customers. As such, it is part of the number of so-called *network utilities*. It is well-known that this situation gives rise to delicate regulation questions given the nature of essential public services, and the conditions of natural monopoly at local level. The use of natural gas distributed by means of a network creates social and individual advantages, such as the safe-guarding of the environment and the elasticity and continuity of the supply. However, the choice for the consumer turns out to be limited at local level. The interfuel competition gives the consumer the possibility of turning to alternative forms of energy, but this opportunity is influenced, at least in the short term, by the costs and times necessary for the substitution of utilisation systems.

Regulation must satisfy many needs. Firstly, it is necessary to pinpoint the cheapest productive structure for the sector with regard to the size and degree of specialisation of the firms. On this subject, European experience provides different answers: in some countries the model of the large vertically integrated national firm has been chosen (England and France), in others there are regional and municipal firms horizontally integrated in the supply of water and electricity (Germany and Belgium). Important indications regarding the above-mentioned different configurations can derive from the analysis of scale and scope economies. The definition of the ownership structure of the distribution firms and the setting-up of the tariff system are equally important. On this question too, the European experience does not offer a consistent solution because, depending on the country, a higher number of public organisations or private firms can be found, as well as different pricing systems. Basically, it is necessary to ensure the economic-financial equilibrium of the firms and to avoid the waste and inefficiency that weigh upon the consumers. This aim can be reached by identifying the factors that objectively influence service costs.

In short, the answer to the many objectives presented above requires the selection of the organisational and territorial variables that, in the real experience of the firms operating in the sector, actually influence the structure and dimension of costs. The econometric estimate of the long-term cost function provides a concise picture that is useful for the interpretation of the role and interaction between such variables and the type of technology of the sector. Moreover, the situation of gas distribution in Italy has a peculiarity that is unique in Europe: it has, at the same time, the highest degree of fragmentation of the offer and a considerable presence of private firms (Rosselli Foundation, 1995). The analysis of Italian operators can therefore offer useful indications for the regulation in other European countries. In addition, the presence of a vertically disintegrated structure can provide useful references for the study of similar sectors, such as the distribution of water and/or electricity.

The following work aims at researching the conditions of service costs for gas distribution in Italy by means of the econometric estimate of a long-term cost function based on disaggregated firm data. As far as the structure of the research is concerned, in the next section some interpretative models deriving from the empirical analysis of the sector are examined. The third section presents the methodology proposed, the explanatory variables and the functional form used. In the fourth paragraph there is a description of the data base, while the fifth one comments on the results of the estimates. Some policy indications are included in section six, while section seven concludes.

2. Previous empirical research

Few empirical contributions on costs and technology in the gas sector are available in the literature. This lack is especially heightened with regards to Europe where productive structures characterised by only one large vertically integrated national operator prevail in major countries. Vice versa, the situation in North America, characterised by greater competition, forms the bulk of most of the available analyses.

The first point of interest concerns the economies of scale and density. On this subject, Guldmann (1983) proposes an analysis by means of suitably neo-classical cost function to consider the specificity of the utility under investigation. It is a multi-output cost function, and the importance of the characteristics of the territory served is highlighted. The costs of the systems depend on the number of customers and the quantity sold to each type of them (residential and non-residential), as well as the density of the population. The price factors are omitted because they are considered constant. In fact, the function is estimated on the data of the territorial divisions belonging to two different firms evaluated separately. A simple linear version as well as a functional firm linear in the logarithms are tested with the following results for the latter:

$$\ln C = 5.675 + 0.245 \ln S_1 + 0.504 \ln N_1 + 0.065 \ln S_2 + 0.099 \ln N_2 - 0.067 \ln D$$
$$(4.82) \quad (1.04) \qquad (2.01) \qquad (2.37) \qquad (1.79) \qquad (-1.57)$$

where: C = Cost of plants, N_1 = N° residential customers (families), S_1 = Volumes sold to residential customers, N_2 = N° non-residential customers (commercial and industrial firms), S_2 = Volumes sold to non-residential customers, D = Density (inhabitants/surface area).

Following the work of Baumol (1977) on multi-product firms, Guldmann analyses scale economies. The latter are indicated by the output elasticity of costs for sales and consumers of the two categories. For the two firms, elasticity is equal to 0.939 and 0.913 respectively. These values lead to the hypothesis of the presence of weak economies of scale that, when tested, turn out to be significant only in the second case. In both functions, however, significant economies of density can be found: an increase of the output over the same territory served produces a less than proportional increase in costs.

In his following work (1984), Guldmann improves the functional form. This study highlights that the output elasticity of costs is not constant, but depends on the market size and territorial concentration of the population served. In addition the analysis shows that the economies of density decrease as the market size increases because of the congestion of urban areas.

Further investigations (Guldmann, 1985) carried out using simulations on the estimated functions enable the author to evaluate the consequences of alternative market forms, characterised by competition. The presence of several firms in the same area, operating competitively on each part of the territory, does not seem advantageous; on the other hand the division of the service to each area amongst the smaller firms would seem to be suitable. The process would turn out to be particularly positive if the firms were specialised in a single kind of customers (residential, non-residentia). The latter observation would mean important policy implications, but the real feasibility of such a theory would have to be checked thoroughly, especially bearing in mind the network constraints.

Productive specialisation and diversification are thoroughly examined by Sing (1987). The author tries to verify whether the firms that provide both electricity and gas are more efficient. This would mean that scope economies exist between the two services (Panzar and Willig, 1977, 1981). A translogarithmic function of the operating costs is estimated, where the base variables are: the quantities sold of the two outputs, the prices of the inputs and the density of the customers on the territory. The estimate is based on 1981 data on a sample of 108 American firms, 43 of which are multi-output, 34 are mainly electrical and 31 are basically geared towards gas distribution. The results are uncertain but they seem to point towards the presence of diseconomies. The higher costs for the multi-output firms can be attributed, according to the author, to the higher qualitative levels of the service offered .

In a more extensive work on tariff levels, Hollas (1990) also deals with the subject of diversification with opposite results. The average cost functions for different kinds of customers are estimated. The Cobb-Douglas functions consider numerous variables such as the quantities sold, the number of customers, the prices of the productive factors, the storage capacity, the density, the degree of productive specialisation, the ownership structures and the forms of regulation. The comparison between private and public firms shows higher costs for the unregulated municipals while lower costs for multi-output firms emerge. The effects of density (measured by the ratio between the number of consumers and the length of the networks) turn out to be extremely positive.

The subject of diversification cannot however be separated from that of regulation and market power. In two studies on allocative efficiency in the sector, Hollas e Stansell (1988, 1994) reach the following conclusions:

. the rigidity of regulation has a negative influence on efficiency;

. multi-output firms (gas and electricity) obtain inferior performances due to their monopoly power in the energy market;

. private firms have a slightly higher total efficiency as compared to public firms.

Millward and Ward's study (1987) on the firms operating in Great Britain prior to the nationalisation of the sector is concerned with the role of ownership structure. The authors, by using a translogarithmic cost function, propose a comparison between public and private firms that does not show any particular differences in performance. The results must however be considered with extreme caution, because the data refers to the end of the last century, and technology then was different from now (firms were vertically integrated and distributed gas that was self-produced by means of the distillation of carbon).

As far as market competitivity is concerned, similar experiences coming from other sectors could be useful. Nelson and Primeaux (1988) examine the relationship between the market and distribution costs of electricity, using a panel of 23 monopolistic and duopolistic American municipal firms. To this purpose, short-term cost functions are estimated where the variables are represented by the quantity of energy supplied, the characteristics of the distribution (number of customers, surface area supplied, length of the network), input prices and by a dummy relative to the market structure. Four versions of the model are estimated, ranging from a Cobb-Douglas to more flexible functions of a translogarithmic type. Greater flexibility improves statistical significance but does not bring about a better explanatory power, since the R^2 is always greater than 0.966. As well as confirming the amplifying effect on costs made by territorial dispersion of the service, the analysis highlights a lower efficiency for the duopolistic structures.

3. A model for Italy

3.1 Technology and explanatory variables

Considering the above leterature and the peculiarity of the situation in Italy, the technology of the natural gas distribution industry is analysed with the following long-term cost function:

$$CD = f(Q,P,H,M),$$

where CD indicates the cost of gas distribution, Q is the output vector, P is the vector of input prices, H is the vector of the hedonistic territorial variables, and M includes some managerial variables.

The model implies a cost minimizing behaviour. This hipothesys seems appropriate because the italian regulation establishes criteria for maximum levels of gas prices while not imposing controls of a rate of return type.

The distribution cost examined is the operating cost (CD) including the purchase of materials and services, labour costs and the depreciation of equipments. The expenses for gas purchases as well a financial costs are excluded. This choice is motivated by the structural characteristics of supply in Italy and by the financial conditions of the operators in our sample. Firms in the industry do not organise the provision of the fuel, which is supplied to all distributors by a publicly owned firm, Snam, on the same price terms. On the other hand, this cost item does not influence the performance of the firms in that the existing tariff norms establish its transferral onto the selling price (Clò, 1992). With regards to capital, the financial cost is not considerated because financial structures are not homogeneous and often a part of the debt costs incurred by municipal firms is payable by the council they belong to.

In the cost function we found an output vector instead of only one quantity variable. This definition is in agreement with the many studies on the network services (Guldmann, 1983, 1984, 1985, 1989; Millward and Ward, 1987; Roberts, 1986; Nelson and Primeaux, 1988; Hollas, 1990; Klein, 1993; Clagget, 1994; Kim and Lee, 1996) and is motivated by the multi-product nature of the service. Since the distribution service makes use of an infrastructure linking every consumer, both the quantity distributed and the number of customers are important. The former influences piping diameter while the latter has an effect on the extension and articulation of distribution network. Furthermore, the clientele turns out to be composed of several categories: residential consumers for domestic use and heating, business and craftsman structures, large hospital and manufacturing plants. Each category has specific needs regarding the way of using gas, requirements, demand continuity and demand seasonality. The same number of consumers can record strong differences in the quantities sold, and vice versa; moreover the presence of homogeneity in volumes and consumers can also have different effects on the costs according to the different mix of customers. Bearing in mind the nature of the data available, the following are indicated as output variables: the average number of consumers (AC), the quantity of gas sold to small and medium size consumers (civil consumption) subject to the regulation of the prices (RS), the quantity sold to large industrial and hospital consumers (OS). This variable presents some values equal to zero; consequently in the estimation procedure it has been transformed by adding one to the original value.

As far as the input prices are concerned, two *proxy* variables are considered: the average labor cost per employee (LC) and the ratio between the book-value of equipment and the length of the distribution network (KC).

The hedonic variables have the function of considering the characteristics of the areas where the service is supplied. The density of the customers needs great attention. There is complete agreement on the importance of this item in literature, while the measurement criteria are somewhat different. Hollas (1990), Hollas and Stansell (1991, 1994), Evrard, Lejeune and Thiry (1994) use the ratio between the number of consumers and the length of the main; Sing (1987) uses the ratio between the consumers and the surface area served; Guldmann (1983, 1984,1985, 1989) and Millward and Ward (1987) refer to the ratio between inhabitants and surface area. The last two measurements mentioned above can be faulted. Though having the same amount of inhabitants, the number of consumers can vary in function of the average size of the household, the diffusion of the service and the consistency of the productive activities. On the other hand, the total surface area of the municipalities does not necessarily correspond to the territory served. This work considers the reciprocal of the density indicated by the ratio between the kilometres of network and the number of customers (D). The variable correctly measures the commitment linked to the dispersion of the customers, because it expresses the capital intensity needed to connect the individual consumers as well as the onerousness of those activities whose logistics depend on the dispersion of the customers: maintenance, checking for leaks and meter readings.

Another territorial component is represented by the level of urbanisation of the areas served (Guldmann, 1984, 1985; Clagget, 1994). This attribute tends to verify the effects of congestion present in the urban areas. In this work it is measured by the concentricity ratio (C). This indicates the share of the population resident in the inhabited areas of the municipalities. It usually takes on a higher value in the big cities, where scattered houses have a minor impact.

The morphology of the territory is an important environmental component, but it is often overlooked in empirical analyses because it is difficult to measure. It seems clear that the set up costs and the management of the distribution network generate costs that are higher or lower depending on whether the gas is supplied in mountainous, hilly or flat areas. This analysis attempts at interpreting this characteristic by including the average altitude of the municipalities served by each firm (AL) as an explanatory variable[1].

The different firm policies and ownership set-ups characterise the vector of the *managerial* variables. In this context, diversification represents one of the most controversial policies within the distribution services of energy and water (Sing, 1987; Nelson and Primeaux, 1988; Hollas, 1990; Clagget, 1994). This strategy can generate synergies reducing cost, but at the same time it envolves regulation problems; it can lead to situations of monopoly in the energy sector wich are harmful for the consumer. The degree of productive specialisation (DS) is measured by the ratio between the employees in the gas sector and the total number of employees of the firm. The joint sales of products that are in competition with one another was not considered, because in Italy competition in the sale of alternative fuels is dominated by tax policies characterised by a prevailing impact of taxation on the price of energy products.

The presence of different forms of ownership controls, including municipal firms, consortia, firms with state shareholdings and private firms, makes it possible to evaluate the role of different agency relationships between the manager and ownership (Arrow, 1985; Borcherding, Pommerehne, Schneider, 1982). A *dummy* variable (DP) is included in order to investigate the relative performance of public firms and private ones.

3.2 The functional form

Literature does not provide clear indications regarding the appropriate functional form, considering the technology of the sector. In some cases, log-linear Cobb-Douglas types have been used, and translogarithmic functions have been used in others. The latter ensure greater flexibility as they do not involve constant elasticity substitution among the productive factors. However, they raise analytical and econometric problems (Sing, 1987; Hollas, 1990), particularly when the sample is made up of a limited number of cases compared to the number of variables in investigation. Given the characteristics of the available data base, the use of a Cobb-Douglas function was considered necessary. The model is specified as follows:

$$lnCD=\alpha_0+\alpha_1 lnAC+\alpha_2 lnRS+\alpha_3 lnOS+\beta_1 lnLC+\beta_2 lnKC+\gamma_1 lnD+\gamma_2 lnC+\gamma_3 lnAL+\tau_1 lnDS+\tau_2 DP+\varepsilon$$

where ε is the error term; it is assumed with normal distribution and $E(\varepsilon) = 0$.

4. The data base

The local gas distribution sector in Italy numbers around 800 operators of different types and sizes. About 30% of the sales is carried out by private firms and the rest by firms with a public set-up: firms with state shareholdings (27% of the sales), municipal firms and local public consortia (43%) (Briotti and Notarangelo, 1995). The data base reflects the market structure. The sample is made up of 31 firms, 10 of which are private and 21 public (municipal firms, consortia and Italgas Group units: State-run firms controlled via Eni). Small, medium and large operators have been included in each category. Most of the firms are located in the Centre-North of the country, but it must be noted that the municipal firms and consortia limit their range of activity to the provincial territory whereas the private firms and those of the Italgas Group often have an operative range that covers many regions and in some cases extend their presence to the Southern regions.

Information regarding 1991 and 1992 was gathered for each firm. Due to the lack of official statistic authorities for the whole sector the data base involved the use of many sources of information and a long task of homogenising the variables.

The economic values were taken from the balance-sheet statements. In the case of firms offering many services, only the figures regarding the gas sector were used. So as to avoid non-homogeneous situations deriving from the balance sheet policies, the depreciation of technical equipments was elaborated once more standardising the

[1] In general, the increase in the elevation corresponds to the switch from flat to hilly or mountainous

average ordinary rate applied by the firms in the sample (6%). The technical-commercial informations (employees, length of the network, consumers, quantities sold) were deduced form the balance-sheet reports or requested directly from the firms. The demographic-territorial indications (population, concentricity, altitude) were obtained by linking two sources: council statistics (taken from the 1991 Istat census) and data about areas served by each firm as listed by the Snam company (1993, 1994).

Table 1 shows some of the descriptive statistics of the total amount of firms studied. It can be seen that the size range is quite wide, especially in terms of employees and consumers. As far as productive factors are concerned, the unitary cost of the equipment systems shows a considerable variability with oscillations ranging from 30,000 to 300,000 lira per network metre, with an average dispersion rate of around 53%. The differences are to be attributed to the age of the plants, their composition, their quality level and also the efficiency costs in its making. The unitary labour cost shows a considerable range (from 36 to 72 million per employee), but records a fairly limited variability (13%); this is also due to the considerable homogeneity of the three labor contracts of the sector. The variability is higher for two ratios: kilometres of network/consumers (46%) and gas employees/total employees (35%), while the differences in the degree of concentricity are limited (6%). Regarding the composition of cost distribution, on average 27% is represented by materials and services purchased abroad, 43% are the labour costs and depreciation accounts for the remaining 30%.

With reference to ownership (table 1), the output of public firms is on average higher with respect to private ones: the ratio is around 2 to 1. The average cost of productive factors is also higher: +19% for labor, and +87% in the case of capital (140 against 75 thousand lira per network metre). The private firms work in territories where there is a lower concentration in the town centres (89% against 93%) and there is a decisively higher dispersion of customers (14,4 against 9,2 network metres per consumer). These aspects, along with the higher altitude of the towns supplied (209 metres against 109), show that private firms have their barycentre veered towards non-urban centres and hilly and mountainous areas. Finally, publicly owned firms turn out to be more diversified (lower impact of employees relative to gas distribution) and have a

areas.

greater impact on labour costs (47% against 36% of distribution costs), compensated by a lower impact of the capital cost (27% against 36%).

5. Results

The estimate of the total cost function previously defined was carried out by means of the ordinary least squared method, and the results are listed in table 2. The explanatory value of the estimated function is particularly good. The R^2 shows that the model explains more than 99.5% of the cost variability within the data base.

Since each firm of the data-base was observed over two years, a cost function including a time dummy variable has been estimated. The hypothesis that its coefficient is equal to zero cannot be rejected at 1% level of significance. This result allows to overlook the presence of fixed yearly effects.

Regarding the single variables, the number of consumers turns out to be the only output component to be significant. This result confirms the prevailing opinion of the sector experts on the low marginal impact of the quantity supplied (customers being equal) on distribution costs. Sales to domestic and large consumers are lacking in statistical significance.

As far as the vector of input prices is concerned, the unitary labour cost is not significant. This result must be considered with care. As previously mentioned, there are significant differences between the single salaries of the public firms and private ones. In particular, the private firms have average salaries that are 16% lower. The non-significance of the variable in question can then be partly explained considering the correlation that exists between the same and the dummy relative to the ownership set-ups. The price of the equipments, on the other hand, shows a significant positive correlation with the cost level. This means that the different conditions of unitary cost in setting up the structure have a great effect on the depreciation size and consequently on the final distribution cost. However, it must be remembered that the strictness of the adopted safety norms affects costs, but these qualitative attributes (quality of the material, depth of the pipes, automatic systems for the uninterrupted monitoring of the network) turn out to be difficult to quantify.

All territorial variables are significant. The dispersion of the customers has a great amplifying effect on the costs. This situation indicates the presence of density economies and can be traced back to two factors. The dispersion increases both the average number of network metres necessary to link the individual consumer and the supply costs, such as meter-readings, repair of breakdowns and maintenance. The estimated function coefficient makes it possible to appreciate the impact of the density economies on total cost. It is possible to carry out a sensitivity analysis by hypothesising number of customers and sales variations, in equal proportion, on the same territorial area served. Table 3 highlights that in the face of a doubling of the average output, with the same network, costs increase only by 45%. With regard to the dispersion range of the sample, cost elasticity with respect to customers and volumes turns out to be placed at around 0.5%.

Concentricity also shows a positive and significant coefficient: as the share of the population resident in the town centres increases, so too do the distribution costs. Since concentricity is higher in the large cities, this result can be explained by the existence of diseconomies linked to urban congestion. It is a matter of difficulties in the running of the service relative to areas characterised by intense flows of goods and people, and by the presence of town-planning and architectural constraints.

The significance of the variable that measures altitude confirms the greater complexity of the service provided in hilly and mountainous areas.

Among the managerial variables, productive specialisation has negative effects. The firms that are diversified in the offer of other public services (particularly electrical, water and environmental ones) obtain cost advantages (scope economies). A high significance of the dummy relative to ownership shows a clear cost differential in favour of private firms. On the same conditions, the latter have values that are around 30% lower than the public ones. The level of efficiency offers an important contribution in the explanation of such a performance, since the physical productivity of the inputs, in particular of labour (consumers/employees ratio), turns out to be different. The gaps highlighted can be partly explained by the differences in the quality levels of the service offered that can not be measured objectively.

The study of scale economies focuses on the multi-size nature of the output. Panzar and Willig (1977) and Baumol (1977) propose the observation of the total cost behaviour on the varying, in equal measure, of all the output. There will be scale economies that are constant, increasing or decreasing to the extent of how the total cost is increasing respectively in equal proportion, lower or higher than that of all the output. In the case of natural gas distribution, the analysis involves the study of the joint effects of the variation of the number of consumers and volumes sold. Considering the nature of the functional form used, the coefficients of the variables referred to above show the output elasticity of the costs and therefore the reciprocal sum of such coefficients highlights the characteristics of scale economies. Since this sum is significantly not different from one, it can reasonably be argued that the natural gas distribution industry in Italy is characterised by constant scale economies.

6. Policy indications

The analysis of the technological characters in the gas sector in Italy has provided results that are consistent with international evidence, but has at the same time shown some peculiarities that must be considered within the current context aimed at the privatisation and liberalisation of the market.

The confirmation of constant scale economies indicates that the local size increase does not reduce the long-term costs. The statement excludes the financial costs (not available for this analysis) which in effect could be lower if large operators have greater contractual power. In any case, the absence of economies of scale ensures that the sector policies aimed at improving efficiency can be independent from the local size of the service. This does not mean that the size level of the firm can always be overlooked. In fact, it must be remembered that diversification activities towards the water and electricity sectors generate scope economies. Therefore, technology would seem to suggest the usefulness of policies geared towards the increase in size of the firms by means of the management of diversified activities within the territories served. This process can create synergies, but at the same time problems linked to the acquisition of monopoly power in the energy sector. In this context a good regulation can create the correct balance between technical efficiency and control of the monopoly rent.

Competitivity and regulation are involved from several points of view.

The importance of the average price of physical capital (unitary value per network kilometre) in outlining cost performance indicates the need for competitivity about inputs. The estimate makes it possible to state that the price for each kilometre of network is certainly influenced by the characteristics of the area where the service is provided, but, *ceteris paribus*, it presents gaps that suggests a change in the management of the biddings for the equipments. The lower average price of the network run by the private sector rather than the public one leads to the conclusion that a greater transparency and competitivity in allocating the new public productive capacity is fundamental.

However, it can be felt that savings in the unitary costs can be more profitably and quickly obtained by means of a parallel activity geared towards a wide competition for the market and greater effectiveness in the tariff system.

It is hard to avoid the situation of natural local monopoly, but a competitive management in the renewal of concessions so as to limit structural and running costs is possible. Alongside such a process there must be a further evolution of the pricing system moving from a sort of cost-plus towards *price-cap*, so as to create stimuli for efficiency to the advantage of the consumer. Moreover, the results of this research reject the hypothesis of a single national tariff, given the influence exerted by the territorial variables. The need to safeguard the qualitative levels of the service leads to the introduction in the tariff devices of qualitative parameters that can be measured objectively (they are already being used in the English model) such as: number of accidents, breakdowns, leaks and interruptions of the service.

7. Conclusions

The estimate of the cost function of Italian natural gas distribution firms has identified a great number of factors explaining the differences in service cost levels.

Having detected the fundamental importance of the number of customers served and the marginal impact of the volumes sold on the cost levels, it is necessary to pay attention to many other variables considered in the research. The work reveals the influence of territorial and managerial factors. The analysis of dispersion of customers shows the possibility of obtaining strong density economies. It is equally important to see the effects of the type of ownership and the role of the unitary cost of plants, with a clear differential in favour of private firms. Then, in order of importance, the concentration of the population in urban areas reveals diseconomies of congestion, the altitude of the towns shows the importance of the territorial morphology and the degree of diversification of the firms indicates the benefits of multi-service offers. The analysis of the scale economies does not point to an optimal size for the firm. Nevertheless it must be considered that small firms can have more difficulty in disposing of financial resources necessary to build structures that guarantee suitable qualitative standards.

The overall results suggest the need of introducing some suitable competitive devices concerning the regulation of input prices and the renewal of the procedures for granting concessions. Finally, a review of the tariff system aimed at recuperating efficiency, in respect of the constraints of a territorial nature and of the safeguarding of the qualitative levels of the service, is desiderable too.

Table 1 - Descriptive statistics of the data base

Variables	Units of measure	Min Value	Max Value	Average total firms	Variation coefficient %	Average private firms	Average public firms
Average number of customers	Thousands	4.0	1062.9	222.2	113.3	113.8	273.8
Volumes sold	Millions of mc	9.0	1207.5	347.6	98.7	212.5	411.9
Volumes sold to domestic customers.	Millions of mc	9.0	973.7	299.8	97.0	186.3	353.9
Volumes sold to large customer	Millions of mc	0.0	236.0	47.7	122.7	26.2	58.0
Vol. Large customers/Total vol. sold		0.000	0.270	0.124	51.9	0.123	0.125
Volumes sold / Customers	mc	561	2858	1938	29.6	2139	1843
Length network	Km	39.1	7694.5	1805.6	97.7	1457.7	1971.3
Length network / Customers	m	3.4	24.1	10.9	45.8	14.4	9.2
Inhabitants on concentric / Total in h.		0.740	1.000	0.917	6.3	0.894	0.928
Average altitude	m	1	405	141	71.9	209	109
Average number of. gas employees		6	2170	422	120.8	157	548
Gas employees/Total employees		0.147	1.000	0.799	35.1	1.000	0.704
Labour cost/Gas employees	Millions £	36.5	72.3	60.7	13.0	53.8	64.0
Customers/Gas employees	no.	433	1777	642	41.3	874	531
Cost of equipments/Length network	Thousands £	30.4	300.3	118.6	53.4	74.7	139.6
Distribution costs	Millions £	611	255887	54436	115.6	19741	70957
External costs/Total distribution costs		0.182	0.465	0.269	22.8	0.281	0.264
Labour cost/Total distribution costs		0.185	0.619	0.433	21.5	0.360	0.467
Depreciation/Total distribution costs		0.169	0.623	0.298	30.3	0.359	0.269
No. cases				62		20	42

Table 2 - Gas distribution costs functions

Variable	Coefficients		t	Significance
AC	α_1	1.046001	(24.781)	0.0000
RS	α_2	-0.024305	(-0.576)	0.5668
OS	α_3	-0.020398	(-0.863)	0.3922
LC	β_1	0.075153	(0.587)	0.5595
KC	β_2	0.363264	(5.300)	0.0000
D	γ_1	0.465575	(6.547)	0.0000
C	γ_2	1.010696	(3.180)	0.0025
AL	γ_3	0.030116	(2.268)	0.0276
DS	τ_1	0.088647	(1.919)	0.0605
DP	τ_2	-0.346560	(-6.466)	0.0000
Intercept	α_0	2.388147	(4.273)	0.0001
AdjR^2		0.9954	F=(1323.670)	0.0000

Table 3 - Density economies in gas distribution

Outputs (customers and volumes sold) (a) [*]	0.5	1	1.5	2	2.5	3
Customer dispersion [*]	2	1	0.667	0.5	0.4	0.333
Index of total distribution costs (b)	0.690	1.000	1.243	1.450	1.634	1.802
Changing in output (Δa/a)	-	1.000	0.500	0.333	0.250	0.200
Changing in costs (Δb/b)	-	0.450	0.243	0.167	0.127	0.103
Cost elasticity (Δb/b)/(Δa/a)	-	0.450	0.486	0.500	0.508	0.513

[*] Mean value of the sample equal to 1.

Bibliography

Arrow K.S. (1985), "The Economics of Agency", in *Agency: The Structure of Business*, Pratt S.W. and Zeckhauser R., Cambridge, MA, Harvard Business School.

Baumol W.J. (1977), "On the proper cost tests for natural monopoly in a multiproduct industry", *American Economic Review*, 67(5), pgs. 809-822.

Borcherding T.E., Pommrehne W.W., Schneider F. (1982), "Comparing the Efficiency of Private and Public Production: The Evidence from Five Countries", in *Nationalökonomie Journal of Economics*, suppl. 2, pgs. 127-156.

Briotti M.G., Notarangelo E. (1995),"Il mercato del gas naturale in Italia tra liberalizzazione e privatizzazione", *Rivista di Politica Economica*, December, pgs.187-219.

Claggett E.T. (1994), "A cost function study of the providers of TVA power", *Managerial and Decision Economics*, 15 (1), pgs. 63-72.

Clò A. (1992), "Regolamentazione e concorrenza nei servizi di pubblica utilità: il caso del gas", *L'Industria*, 13 (2), pgs. 247-268.

Evrard O., Lejeune B., Thiry B. (1994), "Coùt de la distribution d'eau en Wallonie et a Bruxelles, Estimation d'une fonction de coùt hédonique", *Annals of Public and Cooperative Economics*, 65(2), pgs. 333-360.

Fondazione Rosselli (1995), "I servizi di pubblica utilità in Italia", *Rapporto sullo stato e sulle condizioni di sviluppo, 1995*, Torino, La Rosa.

Guldmann J.M. (1983), "Modelling the structure of gas distribution costs in urban areas", *Regional Science and Urban Economics*, 13(3), pgs. 299-316.

Guldmann J.M. (1984), "A further note on the structure of gas distribution costs in urban areas", *Regional Science and Urban Economics*, 14, pgs. 583-588.

Guldmann J.M. (1985), "Economies of scale and natural monopoly in urban utilities: the case of natural gas distribution", *Geographical Analysis*, 17(4), pgs. 302-317.

Guldmann J.M. (1989), "Capacity cost allocation in the provision of urban public distribution utilities", *Growth and Change*, 20(2), pgs. 1-18.

Hollas D.R. (1990), "Firm and interruptible pricing patterns: public versus private gas distribution utilities", *Southern Economic Journal*, 57(2), pgs. 371-393.

Hollas D.R., Stansell S.R. (1988), "Regulation, interfirm rivalry, and the economic efficiency of natural gas distribution facilities", *Quaterly Review of Economics and Business*, 28(4), pgs. 21-37.

Hollas D.R., Stansell S.R. (1991), "Regulation, ownership form and the economic efficiency of rural electric distribution cooperatives*", The Review of Regional Studies*, 21(2), pgs. 201-220.

Hollas D.R., Stansell S.R. (1994), “The economic efficiency of public vs. private gas distribution utilities”, *Annals of Public and Cooperative Economics*, 65(2), pgs. 281-300.

Kim T.Y., Lee J.D. (1996), “Cost analysis of gas distribution industry with spatial variables”, *The Journal of Energy and Development*, 20 (2), pgs. 247-267.

Klein C.C. (1993), “A comparison of cost-based pricing rules for natural gas distribution utilities”, *Energy Economics*, July pgs. 176-182.

Millward R., Ward R. (1987), “The costs of public and private gas enterprise in late 19th century britain”, *Oxford Economic Papers*, 39(4), pgs. 719-737.

Nelson R.A., Primeaux W.J. (1988), “The effects of competition on transmission and distribution costs in the municipal electric industry”, *Land Economics*, 64(4), pgs. 338-346.

Panzar J.C., Willig R.D. (1977), “Economies of scale in multi-output production”, *Quaterly Journal of Economics*, 91, pgs 481-493.

Panzar J.C., Willig R.D. (1981), “Economies of scope”, *The American Economic Review*, 71(2), pgs. 268-272.

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

Sing M. (1977), “Are combination gas and electric utilities multiproduct natural monopolies?”, *The Review of Economics and Statistics*, pgs. 392-398.

Snam (1993,1994), *Aziende distributrici nei comuni serviti dalla rete dei metanodotti*, *Situazione al 31/12/1991*; ibidem, *Situazione al 31/12/1992*.

WORKING PAPER SERIES (1997-1993)

1997

1/97 *Multinationality, diversification and firm size. An empirical analysis of Europe's leading firms,* by Stephen Davies, Laura Rondi and Alessandro Sembenelli, January

2/97 *Qualità totale e organizzazione del lavoro nelle aziende sanitarie,* by Gian Franco Corio, January

3/97 *Reorganising the product and process development in Fiat Auto,* by Giuseppe Calabrese, February

4/97 *Buyer-supplier best practices in product development: evidence from car industry,* by Giuseppe Calabrese, April

5/97 *L'innovazione nei distretti industriali. Una rassegna ragionata della letteratura,* by Elena Ragazzi, April

6/97 *The impact of financing constraints on markups: theory and evidence from Italian firm level data,* by Anna Bottasso, Marzio Galeotti and Alessandro Sembenelli, April

7/97 *Capacità competitiva e evoluzione strutturale dei settori di specializzazione: il caso delle macchine per confezionamento e imballaggio,* by Secondo Rolfo, Paolo Vaglio, April

8/97 *Tecnologia e produttività delle aziende elettriche municipalizzate,* by Giovanni Fraquelli and Piercarlo Frigero, April

9/97 *La normativa nazionale e regionale per l'innovazione e la qualità nelle piccole e medie imprese: leggi, risorse, risultati e nuovi strumenti,* by Giuseppe Calabrese, June

10/97 *European integration and leading firms' entry and exit strategies,* by Steve Davies, Laura Rondi and Alessandro Sembenelli, April

11/97 *Does debt discipline state-owned firms? Evidence from a panel of Italian firms,* by Elisabetta Bertero and Laura Rondi, July

12/97 *Distretti industriali e innovazione: i limiti dei sistemi tecnologici locali,* by Secondo Rolfo and Giampaolo Vitali, July

13/97 *Costs, technology and ownership form of natural gas distribution in Italy,* by Giovanni Fraquelli and Roberto Giandrone, July

14/97 *Costs and structure of technology in the Italian water industry,* by Paola Fabbri and Giovanni Fraquelli, July

15/97 *Aspetti e misure della customer satisfaction/dissatisfaction,* by Maria Teresa Morana, July

16/97 *La qualità nei servizi pubblici: limiti della normativa UNI EN 29000 nel settore sanitario,* by Efisio Ibba, July

17/97 *Investimenti, fattori finanziari e ciclo economico,* by Laura Rondi and Alessandro Sembenelli, rivisto sett. 1998

18/97 *Strategie di crescita esterna delle imprese leader in Europa: risultati preliminari dell'utilizzo del data-base Ceris "100 top EU firms' acquisition/divestment database 1987-1993",* by Giampaolo Vitali and Marco Orecchia, December

19/97 *Struttura e attività dei Centri Servizi all'innovazione: vantaggi e limiti dell'esperienza italiana,* by Monica Cariola, December

20/97 *Il comportamento ciclico dei margini di profitto in presenza di mercati del capitale meno che perfetti: un'analisi empirica su dati di impresa in Italia,* by Anna Bottasso, December

1996

1/96 *Aspetti e misure della produttività. Un'analisi statistica su tre aziende elettriche europee,* by Donatella Cangialosi, February

2/96 *L'analisi e la valutazione della soddisfazione degli utenti interni: un'applicazione nell'ambito dei servizi sanitari,* by Maria Teresa Morana, February

3/96 *La funzione di costo nel servizio idrico. Un contributo al dibattito sul metodo normalizzato per la determinazione della tariffa del servizio idrico integrato,* by Giovanni Fraquelli and Paola Fabbri, February

4/96 *Coerenza d'impresa e diversificazione settoriale: un'applicazione alle società leaders nell'industria manifatturiera europea,* by Marco Orecchia, February

5/96 *Privatizzazioni: meccanismi di collocamento e assetti proprietari. Il caso STET,* by Paola Fabbri, February

6/96 *I nuovi scenari competitivi nell'industria delle telecomunicazioni: le principali esperienze internazionali,* by Paola Fabbri, February

7/96 *Accordi, joint-venture e investimenti diretti dell'industria italiana nella CSI: Un'analisi qualitativa,* by Chiara Monti and Giampaolo Vitali, February

8/96 *Verso la riconversione di settori utilizzatori di amianto. Risultati di un'indagine sul campo,* by Marisa Gerbi Sethi, Salvatore Marino and Maria Zittino, February

9/96 *Innovazione tecnologica e competitività internazionale: quale futuro per i distretti e le economie locali,* by Secondo Rolfo, March

10/96 *Dati disaggregati e analisi della struttura industriale: la matrice europea delle quote di mercato,* by Laura Rondi, March
11/96 *Le decisioni di entrata e di uscita: evidenze empiriche sui maggiori gruppi italiani,* by Alessandro Sembenelli and Davide Vannoni, April
12/96 *Le direttrici della diversificazione nella grande industria italiana,* by Davide Vannoni, April
13/96 *R&S cooperativa e non-cooperativa in un duopolio misto con spillovers,* by Marco Orecchia, May
14/96 *Unità di studio sulle strategie di crescita esterna delle imprese italiane*, by Giampaolo Vitali and Maria Zittino, July. **Not available**
15/96 *Uno strumento di politica per l'innovazione: la prospezione tecnologica,* by Secondo Rolfo, September
16/96 *L'introduzione della Qualità Totale in aziende ospedaliere: aspettative ed opinioni del middle management,* by Gian Franco Corio, September
17/96 *Shareholders' voting power and block transaction premia: an empirical analysis of Italian listed companies,* by Giovanna Nicodano and Alessandro Sembenelli, November
18/96 *La valutazione dell'impatto delle politiche tecnologiche: un'analisi classificatoria e una rassegna di alcune esperienze europee,* by Domiziano Boschi, November
19/96 *L'industria orafa italiana: lo sviluppo del settore punta sulle esportazioni,* by Anna Maria Gaibisso and Elena Ragazzi, November
20/96 *La centralità dell'innovazione nell'intervento pubblico nazionale e regionale in Germania,* by Secondo Rolfo, December
21/96 *Ricerca, innovazione e mercato: la nuova politica del Regno Unito,* by Secondo Rolfo, December
22/96 *Politiche per l'innovazione in Francia,* by Elena Ragazzi, December
23/96 *La relazione tra struttura finanziaria e decisioni reali delle imprese: una rassegna critica dell'evidenza empirica,* by Anna Bottasso, December

1995
1/95 *Form of ownership and financial constraints: panel data evidence on leverage and investment choices by Italian firms,* by Fabio Schiantarelli and Alessandro Sembenelli, March
2/95 *Regulation of the electric supply industry in Italy,* by Giovanni Fraquelli and Elena Ragazzi, March
3/95 *Restructuring product development and production networks: Fiat Auto,* by Giuseppe Calabrese, September
4/95 *Explaining corporate structure: the MD matrix, product differentiation and size of market,* by Stephen Davies, Laura Rondi and Alessandro Sembenelli, November
5/95 *Regulation and total productivity performance in electricity: a comparison between Italy, Germany and France,* by Giovanni Fraquelli and Davide Vannoni, December
6/95 *Strategie di crescita esterna nel sistema bancario italiano: un'analisi empirica 1987-1994,* by Stefano Olivero and Giampaolo Vitali, December
7/95 *Panel Ceris su dati di impresa: aspetti metodologici e istruzioni per l'uso,* by Diego Margon, Alessandro Sembenelli and Davide Vannoni, December

1994
1/94 *Una politica industriale per gli investimenti esteri in Italia: alcune riflessioni,* by Giampaolo Vitali, May
2/94 *Scelte cooperative in attività di ricerca e sviluppo,* by Marco Orecchia, May
3/94 *Perché le matrici intersettoriali per misurare l'integrazione verticale?,* by Davide Vannoni, July
4/94 *Fiat Auto: A simultaneous engineering experience,* by Giuseppe Calabrese, August

1993
1/93 *Spanish machine tool industry,* by Giuseppe Calabrese, November
2/93 *The machine tool industry in Japan,* by Giampaolo Vitali, November
3/93 *The UK machine tool industry,* by Alessandro Sembenelli and Paul Simpson, November
4/93 *The Italian machine tool industry,* by Secondo Rolfo, November
5/93 *Firms' financial and real responses to business cycle shocks and monetary tightening: evidence for large and small Italian companies,* by Laura Rondi, Brian Sack, Fabio Schiantarelli and Alessandro Sembenelli, December

Free copies are distributed on request to Universities, Research Institutes, researchers, students, etc.
Please, write to:
MARIA ZITTINO, Working Papers Coordinator, CERIS-CNR
Via Real Collegio, 30; 10024 Moncalieri (Torino), Italy
Tel. +39 011 6824.914; Fax +39 011 6824.966; m.zittino@ceris.cnr.it; http://www.ceris.cnr.it