Barbara Antonioli and
Massimo Filippini

Optimal size in the waste collection sector

Quaderno N. 01-02

Decanato della Facoltà di Scienze economiche
Via G. Buffi, 13 CH-6904 Lugano. Tel. 091 912 46 09 / 08. Fax 091 912 46 29

Optimal size in the waste collection sector*

Barbara ANTONIOLI
University of Lugano
Department of Economics
Via G. Buffi, 13
6904 Lugano, Switzerland
and
University of Bologna

Massimo FILIPPINI
University of Lugano
Department of Economics
Via G. Buffi, 13
6904 Lugano, Switzerland

February 2000

Abstract: The purpose of this study is to analyze the cost structure of a sample of Italian waste collection firms in order to assess economies of scale and density and, therefore, to define the optimal size of the firms in this sector. A total and a variable translog cost function were estimated using panel data for a sample of 30 firms of waste collection and disposal operating at the provincial level over the period 1991-1995. In both models, results indicate the existence of economies of density and economies of scale for most output levels.

The empirical evidence suggests that franchised monopolies, rather than side-by-side competition, is the most efficient form of production organization in the waste collection industry. Further, the majority of the firms are not operating at an optimal scale. Therefore, the consolidation of adjacent service territories in small provinces is likely to reduce costs.

---

* We are grateful to CISPEL and NOMISMA for general assistance in constructing the database for the empirical analysis. We would also like to thank Gina Poncini for proofreading the final version of this paper. The views expressed in this paper are strictly personal. Responsibility for any remaining errors lies solely with the authors.

1. Introduction

In Italy, the waste sector is undergoing a radical change in organizational and market structure.

Decree 22/97 defines a new economic regulation of the waste sector, aimed at introducing the integrated management of the production process in each regional service area, which generally coincides with the province. However, the regional lawmaker has the faculty to define different confines of regional service areas, in order to reach the optimal size of the service area from an economic point of view. Of course, the correct definition of the optimal size in this industry is linked to the dimension of economies of scale and density.

The purpose of this study is to make a contribution to this debate through the econometric estimation of a translog total and variable cost function for a sample of Italian waste collection and disposal firms operating at the provincial level. This study is useful in order to verify the presence of economies of scale and density and to define an optimal size of the service area. These firms operate as local franchised monopolies in waste collection and disposal in their legally defined service areas.

The production process of the firms operating in the Italian waste-collection sector goes through three phases: garbage collection, treatment and disposal. Generally, we can distinguish two types of firms: the first (Type I) characterized by those that collect, treat and organise the disposal of garbage; the second (Type II) represented by firms which primarily collect and treat garbage. For waste disposal, Italian firms can choose between two procedures: either incineration or landfill. All firms in our sample of Type I firms use the landfill method.

The results of this study are relevant to several regulatory issues. First, they provide information about the validity of the natural monopoly argument in the waste collection sector. Second, they permit judgement to be made about the legal assignment of service areas. Third, they contribute to an evaluation of the definition of the optimal size of service areas.

Both total and variable cost function approaches are used in this study. We decided to use both because each has a unique weakness. The total cost function assumes that the firms are in static equilibrium, using all inputs at their optimal levels. This is a strong assumption, because waste collection firms could have some problems in adjusting their capacity instantaneously. The variable cost model removes that weakness; on the other hand, the inclusion of the capital stock variable in the model specification is likely to increase a multicollinearity problem in the econometric estimation.

This article is organized as follows. Section 2 illustrates the cost model. Section 3 presents the data for the sample of waste collection firms whose cost structure forms the center of interest in this study. Parameter estimates of the total cost function and other empirical results are presented in Section 4. Section 5 presents the empirical results in terms of the variable cost function, in which the capital stock is held constant. The policy implications and the conclusions are examined in Section 6.

2. The cost model specification

Previous studies on the cost structure of waste collection firms are few and outdated. The most relevant studies for our analysis are those by Stevens (1977), Tickner and McDavid (1986) and Antonioli, Fazioli and Filippini (2000). These studies try to analyze how the cost of waste collection varies with the nature of the ownership, size and degree of competition in the market.

Stevens studied the cost structure of waste collection for a sample of 340 public and private waste collection firms in the U.S. from 1974 to 1975. Stevens used a log-linear total cost function with the following explanatory variables: output, price of labor and price of capital. The output is measured in tonnes of waste collected. Empirical results highlight the presence of economies of scale for small cities, while for cities with a population greater than 50,000 there were no economies.

Tickner and McDavid used a log-linear function to analyze the relation between effects of scale and market structure on a sample of 132 Canadian municipalities. The explanatory variables are: output (measured in tonnes of waste collected), the number of households served per tonne of waste, the tonne density, the place of pickup, the frequency of collection, the number of miles waste is hauled to a dump site, the average wage rates and the market arrangement. The main conclusion of this study is that solid waste collection appears to exhibit economies of scale; estimated savings were in the order of 14.5% for a doubling in the size of the pickup unit, measured in terms of the tonnage of waste collected[1].

[1] Since the production of refuse collection services presents various affinities with trucking industries, it could be interesting for the model specification to analyze studies on the cost structure of this sector.

Antonioli et al. (2000) have performed an econometric analysis of economies of scale and density using a total cost function. Their study found evidence for the hypothesis of the presence of economies of scale and density in this industry. The present paper, instead, attempts to estimate both total and variable cost functions in order to address the reliability and consistency of the estimation results obtained using both models.

The two major improvements of this study and of the study by Antonioli et al. (2000) in comparison to the studies by Stevens (1977) and by Tickner and McDavid (1986), are therefore: the utilization of a more sophisticated functional form and a more sophisticated econometric procedure.

For the specification of the cost model we have considered a waste collection and disposal firm with three inputs, labor (L), capital (K) and energy (E), which collects a single output Q on a network of size N. Network size can be defined, for instance, by the length of the roads on the waste collection itinerary.

If it is assumed that the firm minimizes cost and that the isoquants are convex, a total cost function can be written as:

$$CT = C(Q, Pl, Pe, Pk, N, DSM, DRT, DFRE, T) \tag{1}$$

where *CT* represents total cost and Q is the output represented by the total of tonnes of waste collected, and *Pl, Pe* and *Pk* are the prices of labor, fuel and capital, respectively. The size and extent of the network is measured by the length of the roads on the rubbish collection itinerary. DSM is a dummy variable which carries value 1 if firms are Type II (firms which primarily collect and treat the garbage) and 0 value if firms are Type I (firms which collect, treat and organize the disposal). DRT is a dummy variable bearing value 1 if the firm give the treatment of collected waste in outsourcing and 0 value otherwise, DFRE is a dummy variable bearing value 1 if the frequency of collection per week is higher than 3 times, which is the normal frequency adopted by local councils, and 0 value otherwise. T is a time variable which captures the shift in technology representing change in technical efficiency.

The properties of the cost function (1) are that it is concave and linearly homogeneous in input prices and non-decreasing in input prices and output.[2]

Estimation of cost function (1) requires the specification of a functional form. The translog cost function offers an appropriate functional form for answering questions about economies of scale and density.[3] Most important for our purposes, it imposes no a priori restrictions on the nature of technology, allowing the values for economies of scale and density to vary with output. The translog approximation to (1) is

$$\ln(\frac{CT}{P_K}) = a_0 + a_Q \ln Q + a_{PL} \ln(\frac{Pl}{Pk}) + a_N \ln N + \frac{1}{2} a_{QQ} (\ln Q)^2 + \frac{1}{2} a_{PLPL} (\ln \frac{Pl}{Pk})^2 + \frac{1}{2} a_{NN} (\ln N)^2 + a_{QPL} \ln Q \ln(\frac{Pl}{Pk}) + a_{QN} \ln Q \ln N + a_{NPL} \ln N \ln Pl + a_{DSM} DSM + a_{DRT} DRT + a_{DFRE} DFRE + a_T T \quad (2)$$

The price of fuel does not appear in (2) because its value is the same for all firms of the sample.

Note that by normalizing total cost and input prices by one of the input prices, we impose the theoretical condition that the cost function is linearly homogeneous in input prices. In order to improve the efficiency of the estimation of least squares parameter estimates for the cost function, a cost system is estimated. This system consists of the translog cost function (2) and the factor share equation (3). The price by which we normalize is that of the input whose share equation we dropped from the estimating system.

By applying Shephard's lemma, the resulting share equations take the familiar form:

$$S_L = a_{PL} + a_{PL} \ln(\frac{Pl}{Pk}) + a_{QPL} \ln Q + a_{NPL} \ln N \quad (3)$$

where S_L is the share of labor in total costs.

3. Data

The model is estimated for panel data of publicly-owned waste collection firms serving Italian municipalities and provinces.

Our study is based principally on a database managed by CISPEL (The Italian National Association of Local Public Services Firms), which collects financial and production data

[2] See Cornes (1992), p.106.

[3] A translog function requires the approximation of the underlying cost function to be made at a local point, which in our case is taken at the median point of all variables. Thus, all independent variables are normalized

yearly for a sample of 117 waste and disposal collection firms. Additional technical and economic information was obtained from a database on the waste collection sector built up by NOMISMA and from a questionnaire sent to firms.

This collection and merging of information resulted in a sample of 30 waste and disposal collection firms for which all appropriate data are available. For estimations, panel data for five years, 1991, 1992, 1993, 1994 and 1995, have been used.

The necessary data include the total tonnes of waste collected per year, the total km of roads swept per year, the average prices of fuel, capital and labor, the average weekly frequency of collection and sweeping activity and the disposal system.

Total yearly production cost is equated to the sum of direct costs[4], labor costs and capital costs. Average yearly wage rates are estimated as the labor expenditure divided by the number of employees.

Following Friedlander and Wang Chang (1983) and Filippini and Maggi (1993), the capital price is calculated from the residual capital costs divided by the capital stock. Residual cost is total cost minus labor and fuel cost. The capital stock is defined as the number of vehicles used in the firms.[5]

For the variable cost function, variable cost is equated to the sum of labor cost and energy cost, and the capital stock is approximated by the number of vehicles.

In table 1 we present some statistics of the variables considered in the model (1).

Table 1: Descriptive statistics

Variables	*Unit of measurement*	*1.Quartile (small)*	*Median (medium)*	*3.Quartile (large)*
Total cost	Italian Mio £.	6,189	12,488	47,158
Variable cost	Italian Mio £.	3,325	6,614	19,068
Labor price	Italian £ for worker unit	51,331,000	55,786,000	61,333,000
Capital price	Italian £. For capital unit	64,887,000	94,946,000	169,340,000
Capital proxy	Number of vehicles	33	84.5	146
Output	Tonnes of waste collected	23,387	39,395	95,419

at their median point.

[4] Direct costs are costs of purchased goods and services.

[5] Unfortunately no data are available which would allow the calculation of the capital stock using the perpetual inventory method.

Linear Km	Linear Km	14,976	41,121	119,080
Municipality	Number of municipalities	1	3	13
Network	Linear Km	101.14	217.57	509.83
		No of 0		**No of 1**
Dummy Type I	Takes the value 0 or 1	16		4
Dummy for treatment	Takes the value 0 or 1	15		15
Dummy for frequency	Takes the value 0 or 1	13		17

4. Total cost function results

The estimating form of the total cost model consists of equation (2) plus one share equation defined in (3).[6] Estimation was carried out using iterative Zellner's technique (1962). The resulting estimates are equivalent to maximum likelihood estimates, and they are invariant to which share equation is deleted (Barten 1969).

The estimated coefficients and their associated standard errors of the cost model (2) are presented in Table 2. The estimated function is well behaved. Most of the parameter estimates are statistically significant.

Since total cost and the regressors are in logarithms and have been normalized, the first order coefficients are interpretable as cost elasticities evaluated at the sample median. All these coefficients have the expected signs and are highly significant. The output elasticity is positive and implies that an increase in the production will increase total cost. A 1% increase in the quantity of waste collected will increase the total cost by approximately 0.8%.

The cost elasticity with respect to size of the waste collection network is positive and implies that an increase in the length of the network to be swept will increase total cost.

Table 2 Total cost and variable cost parameter estimates (standard errors in parentheses)

Coefficient	Total cost function
a_0	22.840***
	(0.081)
a_Q	0.765***
	(0.049)

[6] To implement this regression system we assume the conventional error specification proposed by Christenseen and Greene (1976).

a_N	0.078**
	(0.040)
a_{PL}	0.524***
	(0.011)
a_{QQ}	0.024
	(0.065)
a_{NN}	0.144*
	(0.080)
a_{PLPL}	0.069***
	(0.011)
a_{QN}	0.098
	(0.060)
a_{QPL}	0.004
	(0.014)
a_{NPL}	0.042**
	(0.014)
a_{DSM}	-0.447***
	(0.073)
a_{DRT}	0.221***
	(0.062)
a_{DFRE}	0.498***
	(0.070)
a_T	-0.003
	(0.016)
Adjusted R^2 for the system	0.877

*, **, ***: significantly different from zero at the 90%, 95%, 99% confidence level.

Labor, diesel oil and capital cost shares are positive, implying that the cost function grows monotonically in input prices. The dummy variable DSM has a significant negative coefficient. This result is not surprising, because Type II firms are not responsible for the disposal of rubbish. The dummy variable representing the outsourcing of collected waste treatment is positive. This result implies that the outsourcing policy, in a perspective of cost analysis, is not appealing. Finally, the effects of the frequency of collection on the cost (DFRE) have a positive impact on the total waste collection and destruction costs.

Parameter estimates of the translog cost function satisfy the regularity condition of concavity in input prices at the median point of approximation, which requires that the own-price elasticities of inputs be negative and that the Hessian Matrix, $\left[\partial^2 C / \partial w_i \partial w_j\right]$, be negative semi-definite. Because homogeneity in input prices and symmetry of the second order terms were imposed, the estimated functions satisfy all regularity conditions of a theoretically valid total cost model.

The inclusion in the cost function of the size of the waste collection network allows for the distinction of economies of density and economies of scale. Following Caves et al. (1984) and Filippini (1998), we define economies of density (ED) as the proportional increase in total costs brought about by a proportional increase in output, holding all input prices and the size of the network fixed. This is equivalent to the inverse of the elasticities of total cost with respect to output,

$$ED_{TC} = \frac{1}{\dfrac{\partial \ln TC}{\partial \ln Q}} \qquad (4)$$

We identify economies of density if ED is greater than 1, and accordingly, we identify diseconomies of output density if ED is below 1. In the case of ED = 1 no economies or diseconomies of output density exist. Economies of density exist if the average costs of a waste collection firm decrease as the volume of waste collected to a fixed length of network increases. This measure is relevant to decide whether side-by-side competition or local franchised monopoly are the most efficient form in the waste collection industry.

Economies of scale (ES) are defined as the proportional increase in total costs brought about by a proportional increase in output and the size of the network and holding all input prices fixed. Economies of scale (ES) can thus be defined as

$$ES_{TC} = \frac{1}{\dfrac{\partial \ln TC}{\partial \ln Q} + \dfrac{\partial \ln TC}{\partial \ln N}} \qquad (5)$$

We identify economies of customer density if ES is greater than 1, and accordingly, we identify diseconomies of scale if ES is below 1. This measure is relevant for analyzing the impact on cost of merging two adjacent waste collection firms.

In order to gain a better idea of economies of scale and density in this industry, we calculated equation (4) and (5) for small, medium, and large firms, respectively.[7] We note

[7] Equations (4) and (5) have been evaluated at the input prices of the median company.

that most indicators for economies of scale and economies density are greater than 1, which means that the majority of the Italian waste collection firms operate at an inappropriately low scale and density level. As expected, the values of the economies of density are higher than those of the economies of scale. Moreover, large firms are characterized by diseconomies of scale. Concerning large firms, it can be concluded that the optimal size of the route network is lower than 500 km and is approximately 400 km.

Table 3. Economies of scale and density – Total cost function

	Small Q = 23.387 t, N= 96 km	*Medium* Q = 39.395 t, N= 213,80 km	*Large* Q = 95.419 t N= 505,23 km
E_D	1.48	1.31	1.15
E_S	1.67	1.19	0.88

The results indicate that generally the cost of serving a market of size *y* over a territory with one firm is lower than the cost of serving the same market with *n* competitive firms.

5. The variable cost function results

In the previous section we utilized a long-run cost function which invokes the assumption that electricity waste collection firms are in static equilibrium, using all inputs at their optimal levels. This section contends that this assumption may be fallacious and presents a specification that allows for the possibility that firms are not in static equilibrium with respect to one factor of production, capital stock. If it is the case that the firms are not in equilibrium with respect to this quasi-fixed input, then measures of economies of scale and density based on estimates of the long-run cost function may be not precise.

The translog variable cost function is written in the same manner as the total cost function (1) except that:

1. variable cost (CV) replaces total cost as the dependent variable. Variable yearly production cost is equated to the sum of labor and energy cost;
2. the price of capital is replaced by a proxy for the capital stock (*K*), which in this study is defined as the number of vehicles used in the firm;
3. the total labor input cost shares is replaced by the variable labor input cost shares.

In this case, the translog variable cost function is:

$$\ln CV = a_0 + a_Q \ln Q + a_{PL} \ln Pl + a_N \ln N + a_K \ln K + \frac{1}{2} a_{QQ} (\ln Q)^2 + \frac{1}{2} a_{PLPL} (\ln Pl)^2 + \frac{1}{2} a_{NN} (\ln N)^2 + \frac{1}{2} a_{KK} (\ln K)^2 + a_{QPL} \ln Q \ln Pl + a_{QN} \ln Q \ln N + a_{QK} \ln Q \ln K + a_{PLN} \ln Pl \ln N + a_{PLK} \ln Pl \ln K + a_{NK} \ln N \ln K + a_{DSM} DSM + a_{DFR} DFR + a_{DRT} DRT + a_T T \quad (6)$$

The estimated coefficients and their associated standard errors of the variable cost model are also presented in Table 4.

Table 4 Variable cost parameter estimates (standard errors in parentheses)

Coefficient	Variable cost function
a_0	22.120***
	(0.074)
a_Q	0.635***
	(0.068)
a_N	0.018***
	(0.036)
a_{PL}	0.477***
	(0.015)
a_{QQ}	0.345**
	(0.136)
a_{NN}	0.004
	(0.061)
a_{PLPL}	- 0.051**
	(0.024)
a_{QN}	-0.132**
	(0.063)
a_{QPL}	0.064**
	(0.026)
a_{NPL}	0.035**
	(0.017)
a_K	0.229***
	(0.057)
a_{KK}	0.598***
	(0.109)

a_{KPL}	-0.073**
	(0.022)
a_{KQ}	- 0.394***
	(0.103)
a_{KN}	0.272***
	(0.042)
a_{DSM}	-0.468***
	(0.572)
a_{DRT}	-0.054
	(0.048)
a_{DFRE}	0.526***
	(0.056)
a_{T}	0.044***
	(0.012)
Adjusted R^2 for the system	0.922

A well-defined variable cost function should be increasing with respect to output and input prices, concave with respect to input prices and non-increasing with respect to capital stock.

The coefficients of output and input prices have the expected signs and are highly significant. The cost elasticity of output is less than 1. This measure indicates, for example, that a 1% increase in the quantity of collected waste will increase the variable costs by approximately 0.86%.

The labor cost share is positive, implying that the variable cost function is monotonically increasing in input prices. The coefficient of capital stock is positive, pointing to increases in variable costs with increases in capacity at the sample median. This result indicates that marginal increases in capital stock cause an increase in variable costs rather than a decrease as normally expected in cost theory.[8]

A possible reason for this result is proposed by Guyomard and Vermersch (1989) and by Filippini (1996), who support the idea that the incorrect sign of the coefficient of the capital stock may be derived from multicollinearity between the output and the capital stock. To determine whether multicollinearity between output and capital stock variables is causing a problem, we follow Judge et al. (1988) and Greene (1993) and examine the simple correlation coefficients among all the explanatory variables as well as the condition number of these variables. We found some values of the simple correlation coefficient greater than 0.9. As expected, these high correlation coefficients are observed between capital stock and output, and between the interaction variables that include output and capital. Moreover, the value of the condition number confirms the existence of a multicollinearity problem.

The existence of this econometric problem does not allow a precise interpretation of the sign of the capital stock and, therefore, a precise the calculation of the values of the economies of density and scale.

In the case of a variable cost function, the definitions of economies of density and scale are modified in the following way:

$$ED_{VC} = \frac{1 - \frac{\partial \ln VC}{\partial \ln K}}{\frac{\partial \ln VC}{\partial \ln Q}} \qquad (6)$$

$$ES_{VC} = \frac{1 - \frac{\partial \ln VC}{\partial \ln K}}{\frac{\partial \ln VC}{\partial \ln Q} + \frac{\partial \ln VC}{\partial \ln N}} \qquad (7)$$

Table 5 presents the estimates of economies of density and economies of scale computed for small, medium, and large firms, respectively.[9] We note that the indicators for economies of scale and economies density for small and medium firms are greater than 1. The These results confirm the empirical results obtained in the estimation of the total cost function reported in Table 4. The values of the economies of scale and density for the larger firms are lower than one and lower than those found in the total cost function. This difference could be due to the econometric problem mentioned before.

Table 5. Economies of scale and density – Variable cost function

	Small Q = 23.387 t,	*Medium* Q = 39.395 t,	*Large* Q = 95.419 t N= 505,23 km

[8] See Chambers (1988).
[9] Equations (6) and (7) have been evaluated at the input prices of the median company.

	N= 96 km	N= 213,80 km	
E_D	1.73	1.21	0.92
E_S	3.69	1.18	0.68

6. Conclusions

The purpose of this study was to analyze the cost structure of the Italian waste collection industry in order to assess economies of density and economies of scale. In particular, policy-makers are interesting in cost information in this industry in order to determine the desirability of competition in the collection sector. A translog total cost function and a variable cost function were estimated using panel data for a sample of 30 waste collection firms over the period 1991-1995.

In both models, results indicate the existence of economies of density and economies of scale for most output levels. However, the results from the variable cost function could be biased due to the presence of multicollinearity between output and capital stock variables.

The empirical evidence suggests that franchised monopolies, rather than side-by-side competition, is the most efficient form of production organization in the waste collection industry. Further, the majority of the firms are not operating at an optimal scale. Therefore, the consolidation of adjacent service territories in small provinces is likely to reduce costs.

References

Antonioli, Fazioli, Filippini "Analisi dei rendimenti di scala per il servizio di igiene urbana in Italia", 2000, forthcoming in "Economie delle fonti dell'Energia e dell'ambiente"

Barten, A.P., 1969, *Maximum Likelihood Estimation of a Complete System of Demand Equations*, European Economic Review, 1, 25-29

Caves, W.C., Christensen, L.R., Tretheway, M.W., 1984, *Economies of Density versus Economies of scale: Why Trunk and Local Service Airline Costs Differ*, Rand Journal of Economics, 15, 471-489

Christensen, L.R., Greene, W.H., 1976, *Economies of scale in U.S. Electric power generation*, Journal of Political Economy, 84, 665-675

CISPEL, *Annuario Ufficiale Economico-Statistico* 1997

Cornes, R., 1992, *Duality and Modern Economics,* Cambridge University Press, Cambridge

Filippini, M., Maggi, R., 1993, *Efficiency and Regulation in the Case of the Swiss Private Railways*, Journal of Regulatory Economics, 5, 199-216

Filippini, M., 1998, *Are Municipal Electricity Distribution Utilities Natural Monopolies*?. Annals of public and cooperative economics, 2, 157-174

Sbandati A., Cima S., 1999, *L'economia dei rifiuti solidi urbani*, Franco Angeli

Stevens, B.J., 1977, *Scale, market structure, and the cost of waste collection*, The review of Economics and Statistic, 60, 438-448

Tickner, G., Mc David, J., 1986, *Effects of scale and market structure on the costs of residential solid waste collection in Canadian cities*, Public Finance Quarterly, 14, 371-391

Zellner, A., 1962, *An Efficient Method of Estimating Seemingly Unrelated Regressions and Test for Aggregation Bias*, Journal of the American Statistical Association, 58, 348-368.

QUADERNI DELLA FACOLTÀ

I quaderni sono richiedibili (nell'edizione a stampa) alla Biblioteca universitaria di Lugano
via Ospedale 13 CH 6900 Lugano
tel. +41 91 9124675 ; fax +41 91 9124647 ; e-mail: biblioteca@lu.unisi.ch
La versione elettronica (file PDF) è disponibile all'URL:
http://www.lu.unisi.ch/biblioteca/Pubblicazioni/f_pubblicazioni.htm

The working papers (printed version) may be obtained by contacting the Biblioteca universitaria di Lugano
via Ospedale 13 CH 6900 Lugano
tel. +41 91 9124675 ; fax +41 91 9124647 ; e-mail: biblioteca@lu.unisi.ch
The electronic version (PDF files) is available at URL:
http://www.lu.unisi.ch/biblioteca/Pubblicazioni/f_pubblicazioni.htm

---

Quaderno n. 98-01
P. Balestra, *Efficient (and parsimonious) estimation of structural dynamic error component models*

Quaderno n. 99-01
M. Filippini, *Cost and scale efficiency in the nursing home sector : evidence from Switzerland*

Quaderno n. 99-02
L. Bernardi, *I sistemi tributari di oggi : da dove vengono e dove vanno*

Quaderno n. 99-03
L.L. Pasinetti, *Economic theory and technical progress*

Quaderno n. 99-04
G. Barone-Adesi, K. Giannopoulos, L. Vosper, *VaR without correlations for portfolios of derivative securities*

Quaderno n. 99-05
G. Barone-Adesi, Y. Kim, *Incomplete information and the closed-end fund discount*

Quaderno n. 99-06
G. Barone-Adesi, W. Allegretto, E. Dinenis, G. Sorwar, *Valuation of derivatives based on CKLS interest rate models*

Quaderno n. 99-07
M. Filippini, R. Maggi, J. Mägerle , *Skalenerträge und optimale Betriebsgrösse bei den schweizerische Privatbahnen*

Quaderno n. 99-08
E. Ronchetti, F. Trojani, *Robust inference with GMM estimators*

Quaderno n. 99-09
G.P. Torricelli, *I cambiamenti strutturali dello sviluppo urbano e regionale in Svizzera e nel Ticino sulla base dei dati dei censimenti federali delle aziende 1985, 1991 e 1995*

Quaderno n. 00-01
E. Barone, G. Barone-Adesi, R. Masera, *Requisiti patrimoniali, adeguatezza del capitale e gestione del rischio*

Quaderno n. 00-02
G. Barone-Adesi, *Does volatility pay?*

Quaderno n. 00-03
G. Barone-Adesi, Y. Kim, *Incomplete information and the closed-end fund discount*

Quaderno n. 00-04
R. Ineichen, *Dadi, astragali e gli inizi del calcolo delle probabilità*

Quaderno n. 00-05
W. Allegretto, G. Barone-Adesi, E. Dinenis, Y. Lin, G. Sorwar, *A new approach to check the free boundary of single factor interest rate put option*

Quaderno n. 00-06
G.D.Marangoni, *The Leontief Model and Economic Theory*

Quaderno n. 00-07
B. Antonioli, R, Fazioli, M. Filippini, *Il servizio di igiene urbana italiano tra concorrenza e monopolio*

Quaderno n. 00-08
L. Crivelli, M. Filippini, D. Lunati. *Dimensione ottima degli ospedali in uno Stato federale*

Quaderno n. 00-09
L. Buchli, M. Filippini, *Estimating the benefits of low flow alleviation in rivers: the case of the Ticino River*

Quaderno n. 00-10
L. Bernardi, *Fiscalità pubblica centralizzata e federale: aspetti generali e il caso italiano attuale*

Quaderno n. 00-11
M. Alderighi, R. Maggi, *Adoption and use of new information technology*

Quaderno n. 00-02
F. Rossera, *The use of log-linear models in transport economics: the problem of commuters' choice of mode*

Quaderno n. 01-01
M. Filippini, P. Prioni, *The influence of ownership on the cost of bus service provision in Switzerland. An empirical illustration*

Quaderno n. 01-02
B. Antonioli, M. Filippini, *Optimal size in the waste collection sector*