An empirical analysis of winning bids in public procurement in the Italian construction sector

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Abstract: - The survival of a construction company depends on its ability to minimize the total cost of production in the long run. The long run cost curves reflect the production technology and the organizational structure of a company. These elements are the result of choices made by the entrepreneur and they are certainly influenced by the economic environment where the company is working. This study analyses the discount of the winning bids in the contracts for public works in the construction industry recorded over a sufficiently large and homogeneous period with respect to general external conditions. Based on known microeconomic models and on some specific assumptions, the winning discounts have been used to draw the long run cost curves. In turn, these cost curves have allowed to detect and classify different business strategies in the organization of companies operating in different Italian regions. The work must be attributed equally to the three authors.

Key-Words: - public sector procurement, winning bids, microeconomic models, business strategy, regression quadratic.

1 Introduction

With the award of a contract, one party (contractor, the *bidder*) assumes the obligation to carry out work or services in favour of another (client, the *Contracting Authority*), in exchange for money.

The first Italian rules on procurement date back to 1865 (Law No. 2248). In 1994 (Law No. 109) a major review of the matter began, partly as a result of the necessary adaptation to the Directives of the European Community (17/18 of 2004). This revision was completed in 2006 by Legislative Decree No. 163 dated 12 April ("Code of public contracts of works, services, and supplies").

The market structure typical of almost all the procedures for the award of public works is the *monopsony*. In this type of market structure there is only one buyer (the Contracting Authority) that requires a good or a service from a multitude of sellers (tenderers/contractors). A Contracting Authority could choose between two different systems for the evaluation of tenders:

Åthe most economically advantageous tender;
Åthe lowest price (sealed bidding).

In the first form, the buyer evaluates the tenders using both economic parameters (price) and other characteristics that concern the technical proposals, such as the architectural quality, organizational quality, and technological features. In the second type of tender competitions - that is the type examined in this paper - the winning bid coincides with the minimum tolerable price by the contractors, namely the one for which the buyer's convenience is maximized.

Numerous studies have tried to identify which the main parameters affecting a bid are. Based on these parameters, different approaches have been proposed to determine the more appropriate level of mark-up. Friedman [13] was the first, that proposed an approach based on the probability theory. The econometric models and regression models followed later [2, 3, 5, 18, 26, 27, 28, 29, 31]. Moselhi et al. [22] used a neural network model to determine the mark-up level after having trained the network using a set of bid cases. Other Authors [1, 8] developed a multi-criteria utility model for bid mark-up. Chua and Li [6] used the technique of the Analytic Hierarchy Process (AHP) to establish the key determining factors in mark-up decision making.

In fact, the bidding strategy of contracting regards the setting of the mark-up to a value high enough to provide sufficient contribution to cover overheads and profit [17], and low enough to ensure

that a sufficient volume of work is achieved in a context of significant uncertainty about the conduct of competitors [7]. These uncertainties are evident in the inability of models already developed in literature to show such a complex reality; this is the reason why many entrepreneurs have little interest in these models [10, 19].

Most of the research identifies common factors affecting the bid [9, 12, 15, 23, 24, 32]. These factors can be attributed to three main categories: 1) the size and complexity of the contract, 2) the type of contract, 3) the economic and competitive conditions (regional market condition). When the contracts involve the construction market, the last factor can obviously identify the geographic location [25, 30]. Clearly, it is not easy to develop realistic models that capture the complexity and uncertainty that control a tender.

2 Aims of the work

The research developed in this work does not have predictive purposes. The objective is the empirical analysis of the behaviour of Italian building firms and their classification according to the national geographical context in which they operate. For this purpose, the study is carried out in individual geographical areas, and with reference to one type of agreement, that is relating to the construction industry. Operating in this way, the size of the contract becomes a crucial factor, given that the number of companies able to realize the works provided in the contract depends on it [14].

The work is divided into four parts. In the first part, the dynamics of winning bids in procedures for the award of public works in the construction sector between 2007 and 2013 are outlined and the regions where the most competitive companies are located are shown, i.e. the building companies capable of winning contracts even outside the region. In the second part, some assumptions of this work are introduced. In fact, the analysis that can be developed in a research also depend on the quality of data available. In the present paper, the database used is not characterized by a particularly high quality, although it has been detected by Reports published by the *Agency for the Supervision of Public Contracts of works, services and supplies*, which is the highest Italian Authority of the public works sector. For this reason, are introduced some working hypotheses consistent with the microeconomic theory of the firm and with the empirical examination of firms operating in the construction sector. In the third part, the shape of the regression function used to interpret the data detected is defined and the corresponding mathematical model is implemented. Finally, the conclusions of the work are derived and the research perspectives are illustrated.

3 General analysis of the construction market in Italy

In the present research the data used are detected by Reports published in 2011 and in 2013 by the *Italian Agency for the Supervision of Public Contracts of works, services and supplies*. These data cover the period between 2007 and 2013 and relate to maximum discounts (winning bids) in procedures for the award of public works in the construction sector (industrial and civil buildings, roads), and classified by region.

Italian regions on which the research has been carried out, have been selected in order to provide an overview able to reflect any differences in the three geographical macro-areas (North, Central, South) of the national territory:

- Campania (South);
- Lazio (Central);
- Lombardia (North).

The comparison between the dynamics of winning bids in the three Italian regions shows that the winning discounts on the contract price in recent years are almost matched (Fig.1). This is certainly the result of increased mobility [11], both national and international, of the economic operators, which is, in turn, a consequence of two factors [16]: on the one hand, the need - generated by the economic crisis - of looking for opportunities [20]; on the other hand, the push for open competition provided by National and European laws.

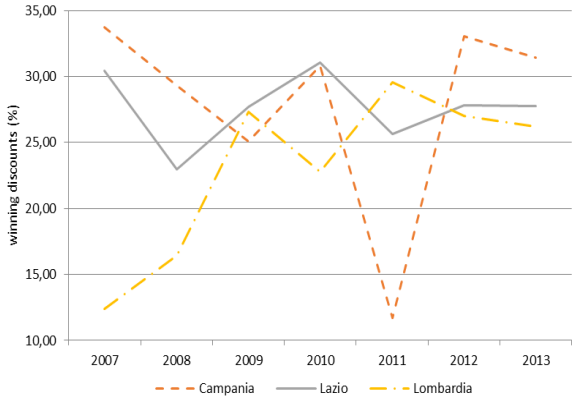

Fig. 1 - Average of winning discounts in procurement for the construction of public buildings

The data observed on the number of contracts won by firms outside their region - i.e. the region where

they have their headquarters -, compared with the ratio between the number of firms in the region and the number of procurement procedures (Table 1), show that the regions with the most ñaggressiveò firms - i.e. able to capture external markets - are precisely the regions where internal competition is strong.

The 2013 Report shows that the Campania region, with reference to companies based in the region, is characterized by the highest ratio of contracts awarded both in the region and externally (= 1.91). Conversely, Liguria is the region characterized by the highest dispersion of domestic demand, that is the highest number of contracts awarded to companies from other regions (compared to the number of contracts awarded to local companies). The Liguria region shows the lowest internal competition (= 0.86).

In economic terms, looking at the value of the contracts, and given that this is an important factor that influences the company mobility, with reference to the regions analyzed in this study, the 2013 Report places the Lombardia region among those regions characterized by the greatest loss in the balance between incoming and outgoing flows (with losses exceeding 60%). On the other hand, the Campania and Lazio regions are among those regions able to generate a positive cash flow (with a balance greater than 35%).

For the purposes described above, in the later stages of the research, the data analysis has focused on a single type of contract, that is the one that recorded the highest number of observations (public building) in the period under observation.

4 Economic analysis

In order to understand the mechanisms that control the procurement market and then to proceed with the classification of companies according to their different regional characteristics, some concepts and models in microeconomics, typical of the theory of the firm, are described below. These concepts allow for the definition, with a deductive approach, of the shape of the regression function used to interpret the observed data.

In a short run condition, the marginal cost curve intersects the curve of the average total cost and average variable cost in their minimum points. The economic optimum point corresponds to the intersection between marginal costs and marginal revenues.

The long run average cost curve, also called ñplanning curveò, is constructed as an envelope of the short run average cost curves. With the aid of this curve, the firm makes decisions on what size of the production plant to use to produce at the lowest average cost. The point at which this occurs is the minimum of the average cost curve and is called the Minimum Efficient Scale (MES) or efficient scale of production.

The long run average cost curve is guided firstly by economies of scale and then by diseconomies of scale. Thus, these factors generally produce a *U-shaped* long run average cost curve.

In this study, the winning discounts (the lowest bid) are used to construct cost curves that represent the organizational structure and the technical and economic capacities of firms operating in the different territorial contexts. Each discount applied is associated with the total price of the contract. The latter, in turn, is assumed as the proxy variable of the size of the contract, that is, the amount of product.

Therefore, a relationship between construction costs and the quantity of goods or services supplied may be drawn up. The line called ñbase price for the tenderò in Figs. 2 and 3 represents the cost per unit discoverable by the bill of quantities. It is possible to hypothesize, with the exception of inflation, that the unit price used as a baseline for tenders is constant regardless of the quantities to be produced. The base price for the tender is determined by the bill of quantities, whose unit prices for each category of work and processes are normally derived from official lists. These official lists, drawn up on a regional basis and annually updated, do not take into account the size of the construction work and have negligible changes in the national setting.

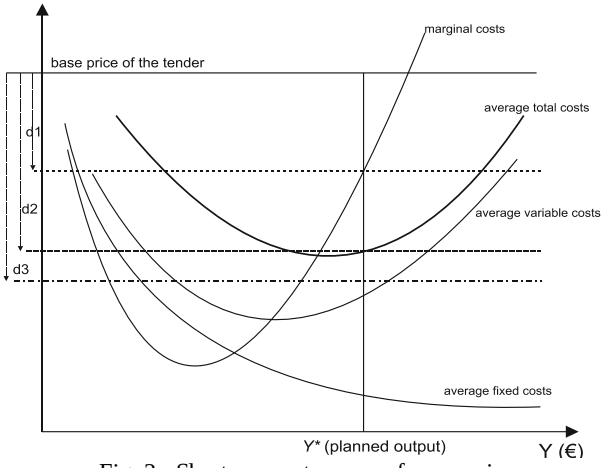

Fig. 2 - Short run cost curves of companies

Table 1 - Analysis of the data detected by the Agency for the Supervision of Public Contracts of works, services and supplies Reports 2011 and 2013

Region	Number of companies	Value of the contracts (ML ù)	Number of procurement procedures	Companies/ Value	Companies / procurement procedures	domestic contracts concluded with companies based in the region	external contracts concluded with companies based in the region	domestic contracts concluded with companies based outside the region	ratio	ratio
						a	b	c	b/a	c/a
Piemonte	2,157	591.36	9,175	3.65	0.24	1,953	554	700	0.28	0.36
Valle d'Aosta	217	69.28	984	3.13	0.22	350	73	155	0.21	0.44
Lombardia	**5,160**	**1,213.92**	**19,856**	**4.25**	**0.26**	**4,297**	**923**	**1,205**	**0.21**	**0.28**
Trento	774	171.08	2,895	4.52	0.27	316	174	259	0.55	0.82
Bolzano	736	167.40	2,409	4.40	0.31	961	61	212	0.06	0.22
Veneto	3,453	605.83	9,041	5.70	0.38	2,661	936	519	0.35	0.20
Friuli V.G.	847	230.96	3,368	3.67	0.25	1,052	132	610	0.13	0.58
Liguria	735	240.16	3,757	3.06	0.20	625	217	537	0.35	0.86
Emilia Romagna	2,028	589.35	9,356	3.44	0.22	1,637	1,026	560	0.63	0.34
Toscana	1,769	492.19	7,397	3.59	0.24	1,690	302	666	0.18	0.39
Umbria	747	74.72	1,120	10.00	0.67	399	244	259	0.61	0.65
Marche	973	182.97	3,015	5.32	0.32	905	156	345	0.17	0.38
Lazio	**4,299**	**558.84**	**7,747**	**7.69**	**0.55**	**2,771**	**1,179**	**610**	**0.43**	**0.22**
Abruzzo	1,196	140.18	2,089	8.53	0.57	640	262	334	0.41	0.52
Molise	296	25.31	382	11.69	0.77	201	97	66	0.48	0.33
Campania	**5,130**	**301.86**	**4,406**	**16.99**	**1.16**	**664**	**1,266**	**176**	**1.91**	**0.27**
Puglia	2,474	289.69	4,308	8.54	0.57	1,516	265	440	0.17	0.29
Basilicata	830	74.16	1,105	11.19	0.75	307	214	155	0.70	0.50
Calabria	1,528	143.77	1,961	10.63	0.78	600	119	214	0.20	0.36
Sicilia	2,853	346.93	5,574	8.22	0.51	1,657	276	276	0.17	0.17
Sardegna	834	246.32	3,798	3.39	0.22	1,270	19	492	0.01	0.39
			average	*6.74*	*0.45*	*1,261*	*405*	*419*	*0.39*	*0.41*

Observing the behavior of a specific company, in the short run and under normal market conditions, the discount efficient - the one that would allow the maximum profit - corresponds (as shown in Fig. 2) to the segment starting line that is identified by the base price for the tender, and it intersects with the curve of the marginal costs. At this point, in fact, the marginal revenue overlaps with the marginal cost. This measure, repeated for different sizes of construction work, allows to draw the costs curve related to a specific firm $C = f(Q)$.

Of course, the optimal discount clashes with the need to win the contract, i.e. the need to compete with the offers of its competitors. For this reason, the company is willing to offer discounts that are greater than the optimal ones. The optimal discount (*d1* in Fig. 2) is created when there are entry barriers or during a phase of strong economic growth. The *d2* discount (Fig. 2) cancels the extra profit and only ensures a normal profit. In extreme cases, the companies could offer prices below the average total costs of production but are at least able to cover the average variable costs: *d3* in Fig. 2 indicates a higher discount that may occur in the case of strong competition consequence, or in a situation of economic recession. Around 2010, in times of economic crisis and strong competition, ñsuicide biddingò was widespread. ñSuicide biddingò is the practice of bidding unusually lower than the other competitors in order to procure work. Companies sometimes adopt the suicide bidding in order to make ensure the work for their skilled staff, even if it only means breaking even on a project or, in some cases, making a loss [4]. In this economic situation, the need for a company to be active in the market pushes towards the formulation of offers regardless of profits and, on the other hand, leads to entry into markets that are geographically distant from the traditional area in which it operates.

The assumptions underlying the analyses carried out are: a) the winning bids are close to or match the maximum bearable discount; b) taking into account the period of data used in this study, the winning bids have discounts corresponding to *d2* shown in Fig. 2, i.e. the one that cancels the extra-profit.

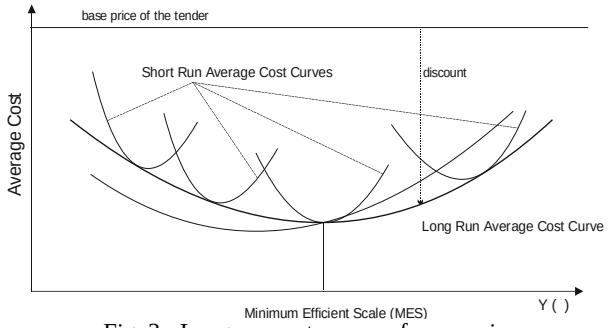

Fig. 3 - Long run cost curves of companies

The highest discount (the lowest bid) coincides with the vertical segment combining -to the construction size (total price of the work) - the average cost curve with the threshold defined by the unit cost resulting from the bill of quantities. Since the winning discounts refer to different companies, which have different sizes of installations and different production capacities, the recorded data can be considered as referring to a long run condition. This means that the curves designed as an approximation of the points identified by winning discounts can be interpreted as long run cost curves of companies operating in different geographical contexts. The curves are obtained by means of a simple non-linear regression.

The *a priori* knowledge of the phenomenon has suggested the use of a polynomial regression of the second degree. As the total price of the contract is used as a proxy variable of the quantities produced, it was necessary to standardize the observed values. This transaction was accomplished through the transfer of all prices to 2013 using the index provided by the Italian National Statistics Institute (ISTAT), concerning the temporal variation in the construction cost of the residential building.

If the implementation of a tender is based solely on fair competition, it is logical to expect that the discounts are concentrated around a fairly limited range. In principle, given the business logic according to which an offer is carefully evaluated and considered, all participants are encouraged to submit the same discount. The winning bid should show this discount or a discount very close to it.

However, the attempt to interpret the data collected with a function capable of capturing only the general phenomenon, economies and diseconomies of scale clash with the presence of other particular factors, which may affect the discount offered.

In particular, there are factors related to the specific business organization such as: the presence of a companyôs active building sites close to the location where the work is to be carried out, the properties of installations for the production of the materials that are to be used extensively in the work, the possession of special patents, etc.

There are also factors related to contracting as in case of "design flaws". Companies offer higher discounts hoping to recover the margin, which they initially give up, followed by a subsequent request for variations carried out during construction, so as to increase the final costs.

Finally, there are environmental factors which are also frequent and widespread throughout the national territory, so-called "disturbance of tender procedure" that generate anomalies in winning bids. In periods of uncertainty or economic crisis, these disturbances can be stimulated by the need to replace the lost income from the proceeds of collusion.

The presence of a ñdisturbance of tender procedureò may be highlighted by the study of the distribution of the discounts offered and by the observation of what such distribution deviates from a condition that should be tendentially normal (*Report No. 11 of 18/03/2004, argument 44 of the Italian Board of the Supervisory Authority of Public Works*). This observation may show a) a lack of competition probably due to the so-called "principle of rotation" or to the promise of the award of sub-contracts to the main contract, b) a concentration of the frequency of discounts at certain intervals, that is an expression of tenders characterized by the phenomenon of cartels.

5 Calculations and results

In order to improve the quality of the analysis and take into account the hypothesis considered, the time interval in which the assumptions are certainly more sustainable is around 2010 (2008-2012). With reference to this time period, the number of data detected by Reports published in 2011 and in 2013 by the *Italian Agency for the Supervision of Public Contracts of works, services and supplies* is: 172 for the Campania region, 166 for the Lazio region and 203 for the Lombardia region.

Taking into account the considerations made in the previous paragraph, the regression function used in this paper to study the relationship between winning discounts and quantity of goods or services supplied, is the quadratic polynomial, and takes the form (1):

$$DISC = \breve{U}\ddot{\imath}\ \eth\, CV + \jmath\, CV^{2} + \mathring{U} \quad (1)$$

where: DISC is the vector of observed winning bids expressed in terms of the percentage discount respect to the starting price of the tender; $\breve{U}$ represents the constant term; $\eth$ and $\jmath$ are the vector

of the parameters to be estimated; CV is the vector of the observed contract values, that is the explanatory characteristic in the regression model developed, expressed in euro; Ů is the vector of random error and stochastic disturbance terms, that is expected to take the form of a normal distribution with a mean of zero and a variance of $\mathring{u}^2$.

In order to prevent the effects on the calibration of the regression model and, consequently, on the reliability of the results, that could be generated by the presence of anomalous data [21], the presence of outliers through the Non-linear Least Squares analysis (NLS) has been preliminarily verified. This test has allowed to identify as outliers the observations showing a residual that exceeds 2.5 times the standard error. In particular, eight outliers have been identified for the ñCampaniaò database and five outliers for the ñLombardiaò database. The NLS dos not identify any outliers in the ñLazioò database. The number of observations used in the final analyses are therefore 164 for the Campania region, 166 for the Lazio region and 198 for the Lombardia region.

The regression model generated on databases without outliers has produced the results reported in Tables 2, 3 and 4 and in Figures 4, 5 and 6.

As may be observed, the model that best fits the observations is the one obtained for the Campania region. However, the indexes of regression verification show that the quadratic polynomial fit on the data of the Lazio region is not to be rejected, as it is the only model that satisfies both the assumptions of normality of residuals (χ-square) and the test of statistical significance of the parameters (*t*-student).

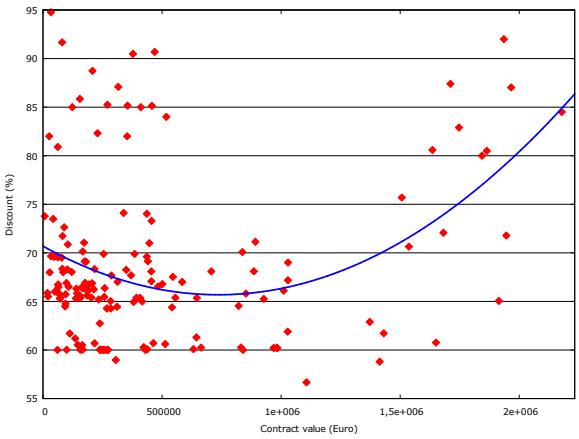

Fig. 4 - The data and the quadratic regression line for the Campania region

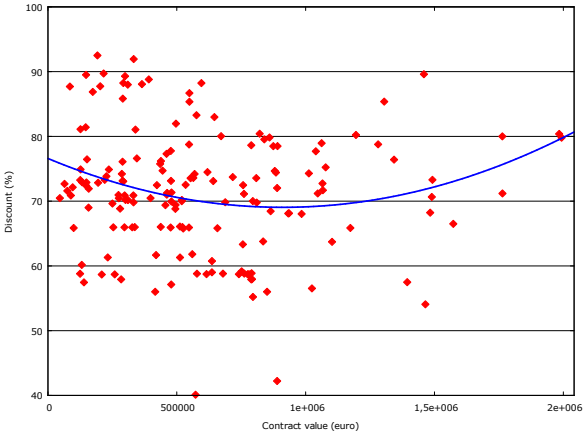

Fig. 5 - The data and the quadratic regression line for the Lazio region

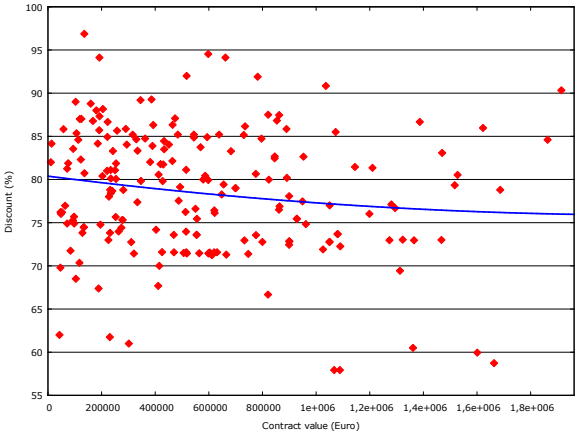

Fig. 6 - The data and the quadratic regression line for the Lombardia region

For a confidence level of 95% (alpha = 0.05), the experimental value of *F* of Fisher exceeds the tabular value in the cases of Lazio and Campania models; the null hypothesis about the non-dependence of the discount on the value of the contract is therefore rejected. This is also confirmed by the *p*-value (always less than 5%) of the *t*-student test conducted on the two parameters that describe the function. It can therefore be confirmed that the relationship between the two variables in the case of Campania and Lazio is approximately quadratic. It also built the interval estimation of two coefficients for a confidence level of 95%. As expected, the two extremes do not contain the value zero.

The models and the corresponding mathematical equations, even though they are only approximate of the phenomenon - especially for the Lombardia model, that has not shown statistical appreciable performances -, have been used for the calculation of the minimum points. They show that the price of the contract in correspondence of which the Minimum Efficient Scale (MES) occurs is respectively equal to ú 2.277.789,22 in Lombardia,

ú 910.742,58 in Lazio and ú 736.307,46 in Campania.

6 Conclusions

The results obtained give rise to some interesting observations. In the years 2007-2013, even though the annual average of winning discounts show a converging upward trend, overall they highlight differences between geographical areas: in the North the average total is in fact much lower than the national average (Lombardia 22,01%); the winning discount then increases moving southwards (Lazio 28.59%, Campania 30.09%). The functions that describe the long-run cost curves have very low coefficients of determination. However, better results could not be expected, given the complexity of the phenomenon, and the difficulty of schematization, as previous researches have already shown. Despite their lack of statistical significance, however, these curves are characterized by feedback and validation which are implicit to the market structure to which they are associated. In fact, the company is also constrained in its choices (and therefore in the discounts offered) by the characteristics of the market in which it operates.

The number of companies doing business in the long run is one of the key features of the market structure; in turn, the cost structure influences the number of companies. Indeed, microeconomic theory states that under conditions of increasing scale returns, i.e. decreasing average costs, there is only one company that operates in the market. If there were more companies, each would produce at a higher average cost than that at which a single firm could produce. The first company that would choose to expand its production could sell a product at a lower price than that of its competitors (thanks to lower production costs), thereby progressively eliminating them from the market and creating a monopoly.

There are also other possible and more frequent conditions: technology, for example, gives rise to an average cost curve with the typical *U*-shape. If the minimum point of this curve occurs at a considerable share of the total output produced by the industrial sector, then it is likely that a few large companies, characterized by dimensions that approach those needed to produce the amount corresponding to the minimum cost, will dominate the sector. Smaller firms would hardly bear the competition with larger companies that are able to take advantage of the descending part of the average cost curve.

Finally, it is probable that technology generates diminishing returns of scale with increasing average costs in the long run or constant returns to scale, with saucer-shaped long-run average cost curves (such a long-run average cost curve with a very large flat portion in the centre can occur if the economies of scale are exhausted at a very modest scale of operation), or, ultimately, *U*-shaped average cost curves, characterized by a production level that ensures a sufficiently low minimum cost with respect to the aggregated output. In this case, it is very likely that a very large number of small companies forms the market structure, as the lack of convenience in increasing the size of the company given the technology used.

The strong competition produces many offers and consequently the possibility of very high winning discounts; this assessment is confirmed by the national "ranking" of the number of certified companies that characterizes the Campania and the Lazio regions.

Table 2 - Descriptive statistics of the analysis on the Campania region

Number of observations	164

Parameter	Estimate	95% Confidence Interval		Standard Error	t	DF	p-value
Constant (Ŭ)	70.6896	68.39	to 72.99	1.1659	60.63	161	<0.0001
ɓ	ī 1.3587e-05	-2.182 E-05	to -5.356 E-06	4.1685 E-06	-3.26	161	0.0014
ɔ	9.2269e-012	4.829 E-12	to 1.362 E-11	2.2269 E-12	4.14	161	<0.0001

Average of dep. var.	68.67043	Standard deviation of dep. var.	8.230258
Sum of Squared Residuals	9,652.838	Residual standard error (RMSE)	7.743095
R-squared	0.125740	Adjusted R-squared	0.114880

Table 3 - Descriptive statistics of the analysis on the Lazio region

Number of observations	166

Parameter	Estimate	95% Confidence Interval		Standard Error	t	DF	p-value
Constant (Ŭ)	76.59	72.92	to 80.26	1.85953	41.196	163	<0.0001
ɓ	-1.656 E-05	-2.622 E-05	to -6.892 E-06	4.8951 E-06	ī 3.383	163	0.0009
ɔ	9.090 E-12	3.030 E-12	to 1.515 E-11	3.0693 E-12	2.962	163	0.0035

Average of dep. var.	71.41084	Standard deviation of dep. var.	9.481839
Sum of Squared Residuals	14,070.05	Residual standard error (RMSE)	9.290821
R-squared	0.052	Adjusted R-squared	0.040

Table 4 - Descriptive statistics of the analysis on the Lombardia region

Number of observations	198

Parameter	Estimate	95% Confidence Interval		Standard Error	t	DF	p-value
Constant (Ŭ)	80.39	77.95	to 82.82	1.2356	65.06	185	<0.0001
ɓ	-3.959 E-06	-1.154 E-05	to 3.627 E-06	3.8461 E-06	-1.03	185	0.3046
ɔ	8.690 E-13	-3.822 E-12	to 5.560 E-12	2.3783 E-12	0.37	185	0.7152

Average of dep. var.	78.56389	Standard deviation of dep. var.	7.196221
Sum of Squared Residuals	9,954.896	Residual standard error (RMSE)	7.144981
R-squared	0.024198	Adjusted R-squared	0.014190

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