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Managerial efficiency and size: an assessment of strategic potential of Italian manufacturing firms

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This paper examines the efficiency differentials with reference to a large sample of Italian manufacturing enterprises. The literature on the subject has frequently emphasized the weakness inherent in a fragmented industrial system. Recently, however, some authors have extensively re-evaluated the role of medium-sized companies, as characterised by a potentially winning combination of "structure" and "flexibility". Applying the nonparametric DEA (*Data Envelopment Analysis*) approach to a set of medium and large firms, the results provide an overview of the disaggregated efficiency components. The medium-small business seems to benefit from the best conditions of efficiency, attributable to a more rational use of labour as well as a more disciplining role of external financial market.

Manufacturing Industries, Operational Size, Efficiency

1. Introduction

Several theoretical and empirical studies identified the excessive fragmentation of production systems as a possible source of weakness in terms of both growth and competitiveness. The harsh worldwide economic crisis, which began in the second half of 2008, has created huge difficulties in most Countries, including Italy. Nevertheless, the system of small and medium-sized Italian enterprises seemed to record, in the current scenario, less difficulty than the major European and American competitors. Such evidence raises questions about the actual impact of firm size on operating performance.

The theory identifies firm size as one component of the overall business performance. From this it follows that a producer could be perfectly efficient from a purely managerial point of view without being, however, at the most productive scale size. On the contrary, a producer may operate at the ideal scale level, while showing, however, operational inefficiencies that negatively impact on total factor productivity. The combination of these two forms of inefficiency can be highly heterogeneous and such a variety of situations can provide very useful information in terms of management decisions and industrial policies.

Beyond considerations on economies of scale, whose nature is essentially technological, firm size might also have an impact on managers' ability to organise

inputs, and thus on managerial efficiency. Despite some arguments highlight that larger firm size may facilitate the achievement of better efficiency conditions (Weiss, 1989), some authors, at least for the Italian context, have recently expressed a more favourable judgement for medium-sized enterprises, whose dynamism and flexibility seems to be higher than that of larger firms (Coltorti, 2005).

Using a sample of manufacturing firms belonging to different industries and observed over the time period 1998-2004, this study aims at providing evidence on this issue and, particularly, on the existence of efficiency gaps related to firm size. Comparing large firms with medium-sized enterprises the purpose of the study is to check whether the latter have an advantage in terms of operational performance.

The efficiency levels of individual producers will be computed using a non-parametric approach known as Data Envelopment Analysis (DEA). DEA has been widely applied to address several decision analysis problems due to its usefulness in estimating the technology and in measuring the performance related to this technology. It therefore allows addressing two basic problems: a) the definition of a performance standard representing the best practice; b) the measurement of the targets which would allow replicating the established standards. In doing so, DEA provides disaggregated information about the components of productive efficiency.

The paper falls within the field of studies on production frontiers, which, as regards the analysis of manufacturing firms, includes a number of contributions based on different methods of analysis, among which Callen (1990), Caves and Barton (1990), Wing and Yiu (1997), Harris (2001), Bottasso and Sembenelli (2004), Bhattacharyya and Saxena (2009), Niringiye *et al.* (2010) (even if only in a few cases the focus is on the dimensional aspect). Interestingly, as discussed in Psillaki and Margaritis (2007), the distance from the efficient frontier could be interpreted as the result of a series of effects related to agency relationships, such as the separation between ownership and control, the existence of incomplete contracts, the effectiveness of different incentive mechanisms and coordination issues.¹

The study is organized as follows. Section 2 describes the issue of firm size with particular reference to comparative studies related to the performance of medium-sized companies. Section 3 describes the database and the selected variables for the evaluation of the efficiency. Section 4 describes the approach used. Section 5 presents and discusses the results. Section 6 presents a possible use of DEA in order to design a strategic model based on the combination of managerial and scale efficiency. Section 7 concludes.

¹ In general, the non-convergence of objectives between managers and owners within a company is expected to have a negative effect in terms of performance due to agency costs, represented, for instance, by costly incentive schemes. Some contributions, however, have called for a rethinking of the agency relationship. The presence of managers more focused on sales or growth rather than on profit targets could, in fact, result advantageous also for owners (Vickers, 1985). For example, to the extent that managers have an incentive to discourage market entry by new players, the owners could take advantage through the maintenance of monopoly profits. Also, it could be argued that the owners might take advantage from a change of incentive schemes, thereby directing the managers towards specific objectives, if there is a reasonable expectation that such actions may trigger the behaviour of the managers of competing companies. For instance, the owners may push to overload advertising expenditures if this may reduce the investment in advertising by competitors (Fershtman and Judd, 1987).

2. The puzzle of firm size

2.1. What size for the firm?

The Italian manufacturing system, consisting of approximately 4 million enterprises, is dominated by small-sized units. 99 per cent of firms have less than 49 employees, and the figure stands at 95 percent when considering units up to 10 employees. The number of firms with a number of employees between 50 and 499 (identified as medium-sized enterprises) are about 20,000 (of which 4,000 industrial), while larger firms, with more than 500 employees, are slightly more than 3,000.

In essence, the above remarks delineate a configuration strongly polarized towards small businesses, mostly family-controlled (Morelli and Monarca, 2005; Grandinetti and Nassimbeni, 2006; Grandinetti, 2007). Such a skewness towards small businesses is seen as a major factor of weakness of the Italian system (De Cecco, 2001, Padoa-Schioppa, 2001; Zanetti and Alzona, 2004; Bianchi *et al.*, 2005).

The firm under- or over-sizing may result in an excess of the average cost due to the under-exploitation or a congestion effect of available inputs. In this context, a topic of great relevance is the link between innovation and firm size. According to Schumpeter's view, large firms are more likely to introduce "radical" innovations. In fact, smaller firms have greater difficulties in financing costs related to R&D activities and the involvement in foreign markets. A study conducted on product innovation of Italian firms (Santarelli, 1999) would seem to indicate a positive relationship between firm size and its ability to realize higher revenue shares from innovative products. Positively correlated to this aspect are then the possibility to attract highly qualified technicians and the availability of appropriate human and financial resources able to facilitate the development of foreign activities with respect to both procurement and contact with end customers. In fact, the concept of scale economies goes beyond the mere size of the production plants and embraces the sphere of support activities such as brand management, design, marketing, after sales services, which are characterized by high fixed costs and therefore by the need to dilute such costs over a high-volume production. In this regard, however, some recent investigations on the Italian case would seem to indicate a particular vitality of the medium-sized business.

2.2. The performance of medium-sized enterprises

Even before the great financial turmoil and subsequent recession that has affected the worldwide economies since the second half of 2008 some studies invited not to neglect the importance of medium-sized companies. These "grow at rates higher than those of large and small enterprises, create jobs and focus on a strong specialization in production that relies on product innovation" (Coltorti, 2005, p. 32).

The survey by Mediobanca-Unioncamere for the year 2003 (Mediobanca-Unioncamere, 2006), examining about 3,900 medium-sized Italian firms equivalent to 13 percent of the value added of manufacturing sectors, has highlighted some specific aspects of medium business as compared to other size classes. Indeed, the

medium-sized business would seem to provide better economic performance. In the period between 1996 and 2003, their value added grew by about 34 per cent against 12 percent of the overall manufacturing industry. Even more brilliant is the performance in terms of exports, with an increase of 43 percent, equal to the rate recorded by large industrial groups in the period 1996-2000 (in the presence of a devaluation of the euro against the dollar by 30 percent) and 14 percent from 2001 to 2006 (in a context of an unfavourable exchange rate), against a balance of 5 percent by large firms. Equally positive is the income profile. Over the period 1997-2000, the real return on investment (ROI) was settled at around 9-10 percent, while during the years 2002 and 2003, characterized by a more critical economic phase, the rates reduced to 6-7 percent. In any case, the time series processed by Mediobanca-Unioncamere show a yield consistently above that of larger Italian companies. The annual R&D surveys (2002-2003) also indicate values equal to those of major multinational companies (Coltorti, 2007).

It is interesting to notice, within the sample examined by Mediobanca-Unioncamere, the presence of about 900 companies at the head of groups that consolidate more than 4,000 operating companies, often of small size. This finding suggests that, in many cases, the dimensional aspect does not concern single producers only but rather more complex organizational structures. In fact, many businesses are small only in legal terms, since they often gravitate into groups of much larger size, from which they draw strategic and financial resources that would probably be inaccessible if they were operating as independent units. In fact, many enterprises of small size have a structure of suppliers and customers which, although independent, assume the role of agents, especially as far as foreign markets are concerned. The decision to separate the business functions, as opposed to the option of keeping them into a single larger firm, is dictated, in general, by the desire to achieve flexibility, to spread risk across multiple operators and not to dilute control. The network of industrial and/or commercial relationships, thereby subtracted from the inner hierarchical control, would seem to ensure the ability to innovate and export.

These considerations reveal the “elastic” nature of the concept of firm size, where relational and qualitative aspects are supporting elements of the value chain (Grandinetti, 2007). The latter take on different forms that range from relationships with suppliers to equity risk in other businesses and choice of strategic alliances. There is also a transversal aspect concerning the skills of human resources and their development. The need to access foreign markets, to give greater value to existing products and to renew the existing products’ portfolio, requires managerial resources with international vocation and a great ability to communicate innovative ideas. Product innovation also requires the acquisition of technical skills as well as the strengthening of relations with external research and engineering centres which make up the value network. By now, all of these resources are not only accessible to most medium and even small businesses, but rather constitute a key element of their success.

These considerations come to support the small and medium size not only according to purely technological factors linked to returns to scale, but also and primarily to their flexibility and thereby their ability to adapt to different situations

as well as their speed in the formulation and implementation of strategic programmes.

3. The database and the determinants of efficiency

3.1. Sample description: industries and size classes

The database is composed of 350 Italian manufacturing firms observed over the period 1998 to 2004, for a total of 2,450 observations. Economic and financial data were retrieved from a panel provided by Ceris-CNR for the period 1998 to 2000, and from annual surveys by Mediobanca for the period 2001 to 2004. Consistently with the aim of this study, both these data sources are focused on large and medium-sized businesses.

In order to have a balanced database, the inclusion of the firms in the sample was subject to the continuity of balance-sheet information along the time horizon. The observed units were then classified into different clusters according to their sector of activity. A subdivision of the firms based on a high level of detail (through the use of multi-digit codes) would have the advantage of generating groups of observations largely homogeneous and, therefore, suitable for the evaluation of efficiency performance based on a logic of horizontal comparison. However, this would have given rise to groups of poor numerical consistency. Consequently broader groups of firms based on 2-digit codes of economic activities as defined by the national bureau of statistics (ISTAT) were created. Such a strategy of aggregation has resulted in the identification of sixteen clusters, each with a sample size adequate for the empirical application.

In accordance with the objectives of the study, we identified three dimensional classes: medium-small firms (50 to 250 employees), medium firms (251 to 1,000 employees) and large firms (over 1,000 employees).²

3.2. Input and output variables

Unlike statistical-based models in which technological parameters are estimated on the basis of pre-specified production functions, the DEA approach does not estimate a direct link between inputs and outputs and thereby avoids assuming a specific shape of the technology. If, on the one hand, this is an indubitable advantage, on the other, the absence of any control for random noise implies that the entire distance from the best practice frontier is interpreted as inefficiency in a deterministic way.³ Moreover, since DEA requires comparisons between homogenous units, we estimated sector-by-sector frontiers.

In DEA applications, the preliminary and most important step is to specify a complete and exhaustive set of input and output variables. In this study, the availability of data sources essentially based on collections of balance sheets has influenced the choice of the variables, which are mostly expressed in monetary

² This size classification is similar to that used by Bianco (2003).

³ For a detailed comparison of parametric methods (with particular reference to stochastic frontier approaches) and DEA, see Coelli *et al.* (2005). In addition, for an exhaustive overview and description of parametric methods, see Kumbhakar and Knox Lovell (2000).

terms.⁴ The final set of variables includes 1 output and 3 inputs. As regards the output we used firm's total revenues, while as regards the inputs we used, accordingly with the prevailing literature, labour, operating expenditures and capital. The labour input is represented by the number of employees. The operating expenditures include purchase costs of raw materials, components and services. Both revenues and operating expenditures were deflated to the base year 2004 using by industry producer price indices as defined by ISTAT.⁵

As regards capital input, the measures typically adopted are: 1) a composed measure built as depreciation plus an implicit cost linked to financial resources; 2) the total value of capital stock. Since these measures are strictly correlated, the choice of either essentially depends on data availability. However, it is necessary to recognise that both these input measures capture the whole stock of production capacity, but not the actual use of the latter, as would be more appropriate.

The first type of capital measure was discarded due to both the unavailability of time series of depreciation costs corrected by firms' fiscal policies and the absence, in the database, of information about the implicit cost of risk capital. In the latter case, in particular, the major difficulty is linked to the fact that the sample largely consists of non-listed companies, for which it is difficult to derive an assessment of the coefficient of systematic risk.⁶

Descriptive statistics on the selected input and output variables are presented in Table 1 by industry. They indicate a notable within-industry size heterogeneity. The mean values also show a certain degree of between variability.

Table 1. Descriptive statistics of output and inputs by industry

Industry	Number of obs.	Revenues (000 euros)		Employees		Materials and services (000 euros)		Net fixed assets (000 euros)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Apparel	84	159,689	0.496	617	0.672	122,234	0.479	19,971	1.074
Food	322	180,278	1.470	486	1.461	141,504	1.386	32,000	1.727

⁴ In principle, any analysis of technical efficiency would require the use of input and output variables expressed in physical terms. The difficulty to have physical data in studies on manufacturing firms requires an 'adaptation' of the concept of technical efficiency. In this sense, the monetary inputs represent the financial commitment by the firm to acquire useful resources to engage in the production process whereas the monetary output would represent the outcome of the transformation activity. Since the efficiency performance is the ability to transform available resources into final outputs as compared to an optimal standard, in this circumstance the efficiency score may be regarded as the relative ability of a firm to maximize the ratio between the market value of output and the economic commitment to access necessary resources (Maietta, 2007). Since this measure inevitably includes the effect of prices (normally excluded from a purely technical assessment of productive efficiency), it becomes close to the concept of profitability.

⁵ In order to minimize distortions we used producer price indices at 3-digit level.

⁶ As regards the net fixed assets, we were not able to deflate annual stock values using the perpetual inventory method because of the lack of a base year and of accurate data on annual investments and divestitures. Therefore, we decided to proceed with the original balance sheet data, although closely monitored at the single firm level. The trend (increasing on average) does not show peaks or other anomalies that would lead to suspect the presence of radical restructuring and revaluation of assets.

Beverages	91	280,09 4	0.92 0	647	1.03 6	215,35 4	0.88 8	71,361	1.067
Paper	84	185,87 7	0.57 9	570	0.77 0	141,82 7	0.57 1	68,513	1.078
Chemicals	329	202,63 5	1.97 6	536	1.09 9	160,99 2	2.21 2	54,380	2.212
Publishing and printing	49	113,026	0.44 2	497	0.76 0	73,848	0.42 1	24,345	0.788
Electrical machineries	91	118,604	0.53 5	772	0.74 4	78,477	0.64 8	18,897	0.521
Appliances	84	213,03 9	0.82 7	892	1.07 7	166,51 6	0.81 0	29,705	1.238
Pharmaceutical	119	291,05 4	0.81 4	900	0.65 2	209,82 0	0.85 5	45,726	0.791
Building	210	156,64 6	0.65 2	637	0.76 9	105,88 6	0.711	46,700	0.825
Furnishings and wood	91	100,36 8	0.38 4	438	0.65 6	76,884	0.39 6	28,536	1.081
Non-electr. machineries	441	122,68 8	0.81 7	558	0.68 7	87,634	0.90 6	18,433	0.850
Metal products	217	168,37 8	0.70 7	330	0.63 3	139,00 1	0.72 5	30,860	0.852
Transportation equipment	84	610,87 4	1.112	1,653	0.96 4	508,96 5	1.16 0	105,40 3	1.804
Leather and footwear	77	142,97 5	0.67 3	474	0.70 2	111,825	0.63 9	13,121	0.775
Textile	77	131,85 0	1.114	807	1.27 6	95,304	1.15 9	28,413	1.186

4. Measuring efficiency differentials

The measurement of efficiency based on the comparison of a firm (or more generally, decision making unit) with its efficient counterpart lying on the technological frontier dates back to Debreu (1951) and Farrell (1957). The basic idea is that the capacity of each unit to transform inputs into outputs cannot be assessed as efficient or inefficient in itself, but only in connection to an external (optimal) benchmark. As a consequence, a firm can be regarded as efficient if it is not possible to identify a benchmark whose processing capacity is better.

Within this approach, the efficiency of a firm is measured in terms of minimising the use of the inputs given a certain amount of output (input-oriented approach) or, alternatively, in terms of maximizing the output given certain input level (output-oriented approach). Of course, the choice between these alternatives depends on the assumption about the firm's behaviour, i.e. the degree of control that individual firms may have in terms of input saving or output expansion. In this context we will adopt the input-oriented approach, since we assume that the amount of output (revenues) is not completely under the control of the firms but may also depend on specific market dynamics.

Charnes *et al.* (1978) and Banker *et al.* (1984) subsequently extended the original intuition by Debreu and Farrell by means of a mathematical approach, based on optimization algorithms, aimed at deriving a technological frontier from a set of

observed units. This approach takes the name of Data Envelopment Analysis (DEA).⁷

Analytically, let $Z = \{(x_n, y_n) \mid n = 1, \dots, N\}$ be a set of N firms for which information is available on the amount of K inputs and M outputs (x_n is a K -dimensional input vector and y_n is a M -dimensional output vector). The input-oriented model in case of variable returns to scale (VRS) for the DMU n_0 , consists in the following linear programming problem (Banker *et al* 1984):

$$\begin{aligned} \min_{\theta_{n_0}, \lambda_n} \quad & \theta_{n_0} & (1) \\ \text{s.t.} \quad & & \\ y_{m,n_0} & \leq \sum_n \lambda_n y_{m,n}, & m = 1, \dots, M \\ \theta_{n_0} x_{k,n_0} & \geq \sum_n \lambda_n x_{k,n}, & k = 1, \dots, K \\ \lambda_n & \geq 0, & n = 1, \dots, N \\ \sum_n \lambda_n & = 1 \end{aligned}$$

where λ_n is a N -dimensional vector of weights (or “intensity variable”) assigned by the linear programming algorithm to each firm in order to determine input/output linear combinations belonging to the efficient frontier. The solution to the linear programming problem provides the optimal value of the scalar θ_{n_0} , such that $0 < \theta_{n_0} \leq 1$. This represents a measure of radial projection towards the frontier. A value of the latter coefficient equal to 1 indicates full efficiency, while a value below 1 indicates an inefficiency of $1 - \theta_{n_0}$. For instance, a score θ_{n_0} of 0.8 indicates an inefficiency of 0.2, thus suggesting that the firm may reduce the use of inputs by 20 percent without changing the output. The last equality constraint provides flexibility in terms of scale economies. It allows to compare each unit against a subset of peers characterised by similar size, therefore avoiding comparison between units operating at different returns to scale regimes. The efficiency measure calculated in this way is thus net of any effect on average productivity due to economies of scale, and efficiency differential would only reflect managerial factors.

Dropping the last constraint, the efficiency scores are calculated under the hypothesis of constant returns to scale (CRS), in which the scale and pure managerial effects are not separated. Analytically, the scale efficiency (SE) can be measured as the ratio of CRS and VRS efficiency scores: $SE = \theta_{n_0}^{CRS} / \theta_{n_0}^{VRS}$. A value

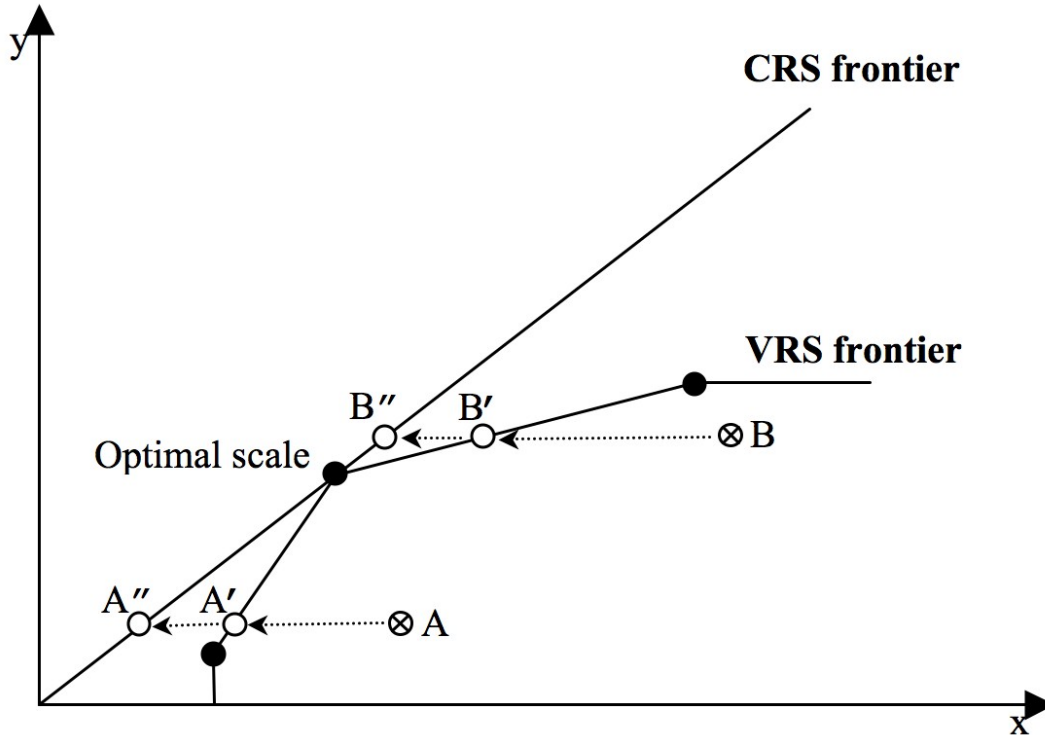
⁷ For a comprehensive discussion of DEA models see Thanassoulis (2001) and Coelli *et al.* (2005).

of scale efficiency equal to 1 indicates that the firm operates at the most productive scale size. Scale efficiency values lower than unity may be due to under-sizing or over-sizing problems. By comparing observed and optimal scale size, the model allows to identify the presence of local increasing returns to scale (IRS) or decreasing returns to scale (DRS).

Figure 1 illustrates the methodology by means of a simplified one-output one-input technology. The CRS and VRS frontiers are determined by “enveloping” the observed units. The distances $B'B$ and $B''B$ identify respectively the CRS (overall) and VRS (pure managerial) inefficiency. In contrast, the distance $B''B'$ identifies a scale inefficiency associated with over-sizing with respect to the most productive scale size, thus indicating the presence of local decreasing returns to scale. Analogous measures of (in)efficiency may be calculated with respect to the unit A. In this case, the scale inefficiency is due to under-sizing and reveals the presence of local increasing returns to scale.

It should be noted that the industry-specific average efficiency scores depend on the distance from the respective DEA frontiers. It follows that cross-industry efficiency comparison is not allowed. However, the industries characterized by higher standard deviation may be regarded as those in which it is more necessary to strengthen the logic of benchmarking in order to enhance convergence towards the goal of optimizing the use of available resources. Moreover, levelling the performance, by encouraging, for instance, the adoption of more efficient technologies, may represent the basis for a shift of the technological frontier.⁸

Figure 1. CRS and VRS efficient frontier



⁸ In this respect, credit institutions may have an important role in order to stress the need for comparative performance assessments, especially in the evaluation of firms' solvency risk.

5. Results

5.1. Overall, scale and pure managerial efficiency

Average values of overall efficiency (measured with reference to the CRS frontier), pure managerial efficiency (measured with reference to the VRS frontier) and scale efficiency (SE) are presented in Table 2.

Table 2. Overall, pure managerial and scale efficiency by industry

Industry	Overall efficiency (ET _{CRS})			Pure managerial efficiency (ET _{VRS})			Scale efficiency (SE)		
	Media	Min	SD	Media	Min	SD	Media	Min	SD
Apparel	0.857	0.661	0.075	0.897	0.735	0.068	0.956	0.683	0.063
Food	0.847	0.693	0.070	0.897	0.720	0.072	0.945	0.837	0.044
Beverages	0.910	0.790	0.060	0.940	0.818	0.054	0.969	0.851	0.031
Paper	0.861	0.592	0.101	0.912	0.602	0.088	0.945	0.754	0.071
Chemicals	0.819	0.500	0.095	0.867	0.580	0.089	0.945	0.629	0.060
Publishing and printing	0.927	0.765	0.075	0.972	0.833	0.040	0.954	0.776	0.067
Electrical machineries	0.889	0.648	0.093	0.935	0.678	0.079	0.950	0.787	0.052
Appliances	0.905	0.709	0.062	0.943	0.728	0.059	0.960	0.838	0.040
Pharmaceutical	0.811	0.571	0.119	0.881	0.616	0.102	0.922	0.621	0.086
Building	0.711	0.495	0.117	0.801	0.583	0.120	0.892	0.585	0.100
Furnishings and wood	0.933	0.781	0.053	0.961	0.782	0.051	0.971	0.882	0.033
Non-electr. machineries	0.794	0.588	0.079	0.839	0.594	0.085	0.949	0.680	0.054
Metal products	0.931	0.683	0.041	0.949	0.762	0.039	0.981	0.896	0.021
Transportation equip.	0.937	0.813	0.049	0.967	0.826	0.038	0.969	0.862	0.041
Leather and footwear	0.896	0.791	0.066	0.943	0.824	0.050	0.950	0.816	0.046
Textile	0.883	0.714	0.083	0.934	0.755	0.060	0.945	0.772	0.061
Total	0.845	0.495	0.104	0.892	0.580	0.093	0.947	0.585	0.062

Notes: CRS stands for Constant Returns to Scale; VRS stands for Variable Returns to Scale
SD stands for Standard Deviation

The average overall efficiency score for the entire sample (ET_{CRS}) is equal to 0.845. This means that in order to replicate the performance of the best units, an equi-proportional reduction of all inputs by 15.5 percent is needed. This figure however does not take the technological constraints represented by firm size into account. Removing the scale effect, the required input reduction decreases to 10.8 percent. The remaining inefficiency should be absorbed through a redefinition of the operational scale. Exploiting DEA properties, the overall efficiency can be decomposed into a pure managerial component (ET_{VRS}) equal to 0.892 and a scale efficiency component (SE) equal to 0.947, thus highlighting a greater impact of the managerial component, even if such a result requires further specification, as will be shown in the section dedicated to the stratification of the sample based on firm size

(see Section 5.2).⁹ Anyway, comparing by industry average efficiency values, we observe that the scale component is structurally higher than the managerial one. This would seem to suggest a widespread lack of management skills rather than a problem of sub-optimal size.

The scale efficiency measures in Table 2 do not distinguish between increasing or decreasing returns to scale regimes. The nature of returns to scale can be verified by examining the distribution of the observed units in the two aforementioned situations (Table 3). Out of 16 industries, 11 are characterised by prevailing increasing returns to scale, thus indicating a diffused under-sizing tendency.¹⁰

Table 3. Percentage of firms exhibiting increasing returns to scale (IRS) and decreasing returns to scale (DRS) by industry

Settore	IRS	DRS
Apparel	70.24	22.62
Food	77.64	18.63
Beverages	59.34	31.87
Paper	51.19	35.71
Chemicals	40.12	51.37
Publishing and printing	30.61	44.90
Electrical machineries	47.25	34.07
Appliances	51.19	39.29
Pharmaceutical	54.62	36.13
Building	49.52	44.76
Furnishings and wood	51.65	32.97
Non-electr. machineries	53.74	43.76
Metal products	36.41	53.00
Transportation equip.	38.10	40.48
Leather and footwear	68.83	14.29
Textile	22.08	63.64
Total	51.96	39.27

5.2. Efficiency and firm size

As noted in the above description of the dataset, our main attempt is to investigate the role of medium-sized firms. Table 4 presents the average efficiency scores relative to 81 enterprises of medium-small size (up to 250 employees), 222 enterprises of medium size (between 251 and 1,000 employees) and

⁹ In this regard, it should be noted that DEA allows disentangling pure managerial and scale efficiency components only at the single firm level. By averaging the efficiency scores, the above decomposition is only approximated.

¹⁰ The 51.96 percent of all the observations is characterized by increasing returns to scale while the 39.27 percent by decreasing returns to scale. The two percentages do not add up to 100 percent due to the lack in the calculation of the units operating at the optimal level (which account for 8.78 percent).

47 enterprises of large size (over 1,000 employees). The results indicate a clear superiority of medium-small class, with an average overall efficiency equal to 0.889, as compared to average scores equal to 0.838 and 0.831 for large and medium size classes respectively.¹¹ By observing single efficiency components, it appears that the medium-small class overcomes the class of large firms by 5 percent in terms of scale efficiency and the class of medium firms by 5 percent in terms of pure managerial efficiency.

In addition, the characteristics of the three groups seem to differ on the basis of the non-parametric Kruskal-Wallis test, at a significance level of 1 percent.¹²

Figure 2a. Percentage of medium-small units with values of global efficiency (ET_{CRS}) above the industry mean

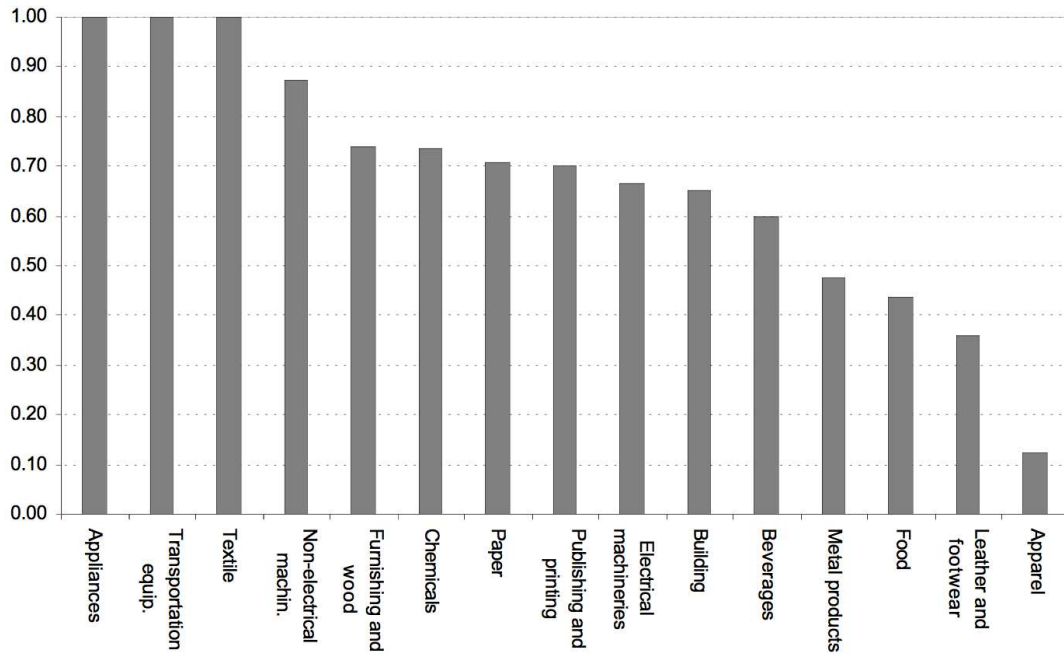


Figure 2b. Percentage of medium-small units with values of pure managerial efficiency (ET_{VRS}) above the industry mean

¹¹ Efficiency scores presented in Table 4 were computed by pooling efficiency values across industries. This is justified by the fact that efficiency scores were calculated with respect to by industry frontiers and thereby they are cleaned by technological heterogeneity. A similar argument applies with respect to results shown in Table 5.

¹² The nonparametric Kruskal-Wallis test is used to verify the hypothesis that different samples come from the same population.

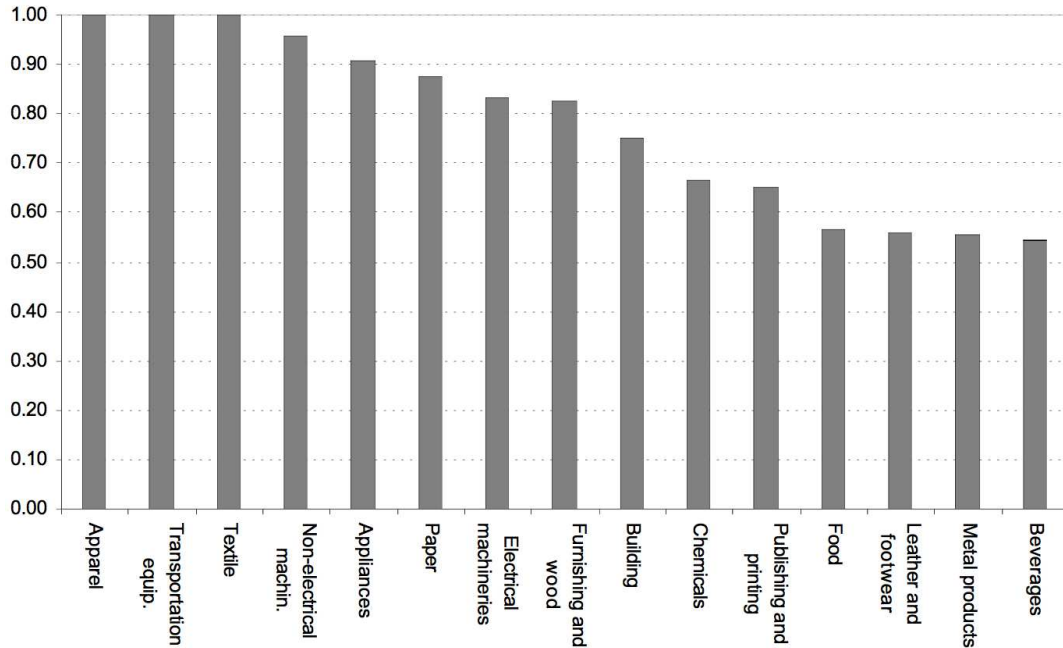
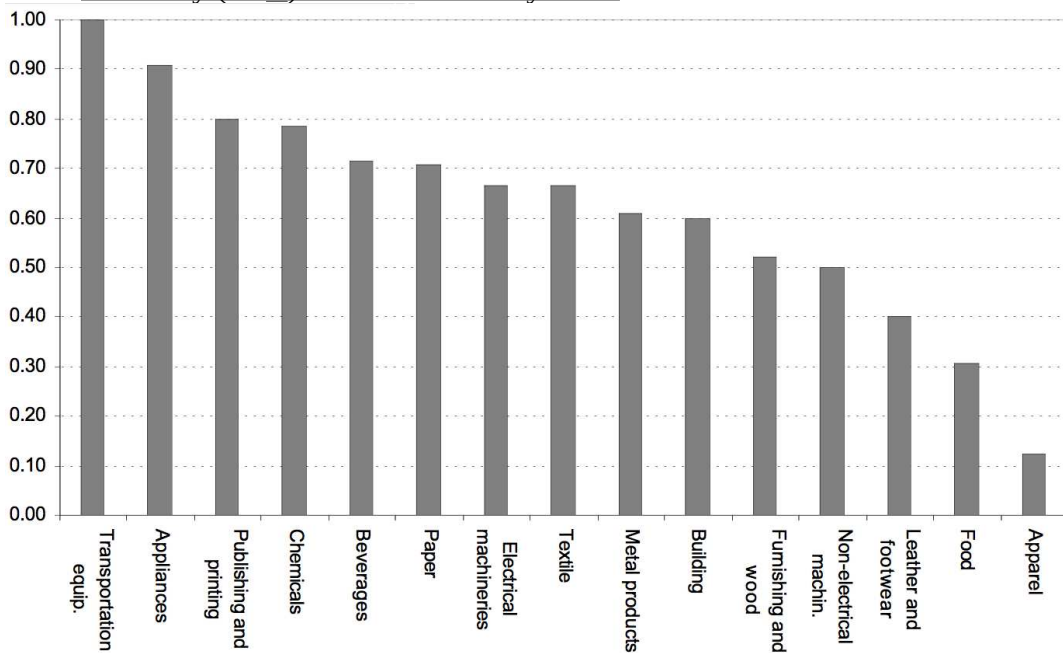


Figure 2c. Percentage of medium-small units with values of scale efficiency (ET_{SE}) above the industry mean



The analysis of size has been further investigated in Figures 2a, 2b and 2c, which report for each industry the percentage of medium-small firms presenting a global, managerial and scale efficiency above the corresponding mean.¹³ The results indicate that, with respect to the pure managerial performance management (ET_{VRS}), in all industries more than 50 percent of medium-small firms is above the average. The same is true also with respect to overall efficiency (ET_{CRS}) and scale efficiency (SE) in, respectively, 11 and 12 industries.

¹³ The sectors represented in Figures 2a, 2b and 2c are 15 instead of 16. This is due to the fact that the pharmaceutical industry does not include medium-small units.

These results do not support the idea that mergers should be favoured in order to achieve larger size. Contrary to some arguments in favour of large businesses, our study reveals that the presence of scale-related inefficiency due to decreasing returns would only partially be offset by gains from the managerial side. Indeed, the medium-small size does not seem to impede the ability to efficiently organise production factors. Accordingly, a recent survey by the Bank of Italy argues that the “term ‘small size’ should be interpreted in a flexible way. Interviews with entrepreneurs have shown that there are small firms that have an established base of suppliers and a network of large customers that, although independent, in fact operate as agents of the company” (Brandolini and Bugamelli 2009, p. 12). Moreover, our study suggests that greater attention should be put on the “medium” attribute. Indeed, companies with more than 250 and less than 1,000 employees appear as the least efficient. In other words, the relationship between size and managerial efficiency seems to follow a U-shaped pattern, which rewards “structure” with regard to large size and “flexibility” with regard to medium-small size, as opposed to the intermediate class in which these issues appear more blurry.

Table 4. Efficiency performance by size class

Size class	Overall efficiency (ET_{CRS})	Pure managerial efficiency (ET_{VRS})	Scale efficiency (SE)
Large	0.838	0.930	0.901
Medium	0.831	0.869	0.956
Medium-small	0.889	0.935	0.951
KW test	130.5***	272.9***	133.7***

Notes: CRS stands for Constant Returns to Scale; VRS stands for Variable Returns to Scale; KW test reports the Kruskal-Wallis statistics on the null hypothesis that different samples originate from the same distribution; *** statistical significance at 1 percent.

5.3. Interpreting the performance of medium-small business: the role of labour and debt

5.3.1. The role of labour input

The DEA methodology allows disaggregating the inefficiency score, by highlighting the role of individual inputs. The coefficients of input over-use presented in Table 5 were calculated as the ratio between observed and target input level. These measures therefore assume values greater than 1, resulting equal to unity in the case of absence of over-use.¹⁴ On average, the over-use indices with respect to operating costs, labour and capital are equal to 13.5, 20.7 and 29.3 percent, respectively. The values also differ between size classes at a significance level of 1 percent.

¹⁴ The DEA input-oriented model identifies the potential for input saving given the output level. By construction all the inputs should be reduced by the same proportion. However, the DEA model allows identifying specific measures of excess input. More particularly, once a unit has been projected radially on the frontier, there can still be room for reduction in specific inputs, referred to as input slack (s_k , $k = 1, \dots, K$), such that the target value of k -th input is equal to: $x'_{k,n0} = \theta_{n0} x_{k,n0} - s_{k,n0}$. A multi-stage DEA approach (adopted in this study) has been developed to minimise the presence of input slacks.

Table 5. Input over-use coefficients by size class

Size class	Materials and services	Employees	Net fixed assets
Large	1.085	1.208	1.199
Medium	1.167	1.255	1.313
Medium-small	1.075	1.076	1.294
Total	1.135	1.207	1.293
KW test	270.8***	294.9***	129.7***

Notes: KW test reports the Kruskal-Wallis statistics on the null hypothesis that different samples originate from the same distribution; *** statistical significance at 1 percent.

The highest over-use value is observed with reference to capital input, with values ranging between 20 to 31 percent. The phenomenon may be associated with the difficult business cycle during the years 2002-2004 and the reduced saturation of production capacity that followed. The most interesting result, however, concerns the use of labour. In this case, the over-use indicator ranges between 8 for medium-small firms and 26 percent for medium firms. Moreover, in the latter case, a less favourable situation with respect to all inputs is observed. Interestingly, as shown in Table 6, the best performing medium-small class is also associated with the highest average labour cost (about 41,000 euros, against 39,000 for large and 38,000 for medium-sized firms). The class of medium-small enterprises presents, therefore, a higher average labour cost and simultaneously the best performance in the over-use of that input. The need to face a higher market price makes the choice of the input more consistent with the optimal standard. An additional interpretation is that medium-small firms would use human resources of better quality that may enable them to achieve a significant competitive advantage. In a nutshell, the argument relating to a reduced capacity of the smaller size to aggregate high-quality workforce does not seem to be confirmed by this analysis. This aspect, however, would need further inquiry.

Table 6. Average labour cost by size class

Size class	Average labour cost
Large	39,096
Medium	37,814
Medium-small	41,200
Total	38,767
KW test	70.3***

Notes: KW test reports the Kruskal-Wallis statistics on the null hypothesis that different samples originate from the same distribution; *** statistical significance at 1 percent.

5.3.2. The role of debt

A second useful interpretation of the performance of medium-small firms is represented by the role of debt. Stemming from the seminal work by Jensen and Meckling (1976) an extensive literature has been developed on this topic, aiming at exploring the key theoretical and empirical relationship between the capital structure and the agency relationships between owners and managers. Such a literature helps

to explain, in several respects, how different choices of financial structure may mitigate agency costs, may reduce inefficiency and may improve performance (Harris and Raviv, 1991; Myers, 2001). The disciplining effect of debt could occur through an increased risk of failure or even liquidation, to which managers would pay attention because of the adverse affects on compensation and reputation (Grossman and Hart, 1982; Williams, 1987). An extension of this thesis is provided by Sena (2006), whereby an increase in financial pressure, coupled with the perception of permanent negative shocks, would induce workers to improve technical efficiency and reduce waste. From another perspective, the disciplining effect associated with debt would find expression in managers' perception of the need to generate cash flow in order to pay debt-holders, or at least not to waste it in projects with no potential value (Jensen, 1986). An interesting empirical analysis on the relationship between efficiency and leverage is also provided by Margaritis and Psillaki (2007), in a DEA framework. The complexity of the phenomenon suggests, however, caution in the interpretation of results, since the relationship between leverage and performance may be subject to a problem of reverse causality. In this framework, the efficiency may be regarded as a possible determinant of the capital structure, as extensively argued by Berger and Bonaccorsi di Patti (2006).

In light of these considerations, some merely descriptive indications about the connection between efficiency and debt ratio (measured as the ratio between firm's short or long-term debt and total liabilities) is presented in Table 7. On the basis of the Kruskal-Wallis test, while the incidence of long-term debt appears to be substantially homogeneous among the different classes, the incidence of short-term debts appears to increase as firm size decreases. This evidence supports conjectures about the disciplining role of short-term debt in the segment of medium-small firms, which show, as noted above, a managerial efficiency comparable to that of larger enterprises. Although the impact on efficiency has so far been little explored in the literature, one possible interpretation of this result is that these forms of debt have a high turnover rate, because they are subject to more frequent repayments to lenders.

Table 7. Incidence of short-term and long-term debt on total liabilities by size class (percent)

Size class	Incidence of short-term debt on total liabilities	Incidence of long-term debt on total liabilities
Large	0.131	0.098
Medium	0.162	0.100
Medium-small	0.196	0.091
Total	0.166	0.098
KW test	27.7***	3.3

Notes: KW test reports the Kruskal-Wallis statistics on the null hypothesis that different samples originate from the same distribution; *** statistical significance at 1 percent.

6. Using DEA in a strategic model

In this section we analyze a possible use of the DEA methodology to construct a strategic model borrowed from the BCG portfolio planning model. The units analyzed were classified according to their level of managerial and scale efficiency

in four categories: *Star* (when both TE_{VRS} and SE scores are above the respective mean values), *Dog* (when both these measures are below the mean), *Long-Run Question Mark* (when TE_{VRS} is above and SE is below the mean) and *Short-Run Question Mark* (when TE_{VRS} is below and SE is above the mean). The distinction between the two definitions of Question Mark depends on the time horizon over which the actions taken to face the critical issues can take place. In particular, the long-term horizon reflects the option of redefining the operational scale in a context of a satisfactory managerial efficiency while the short-term horizon relates to the case in which a reduction in input use is needed in the context of productive scale close to the optimal level.

The results are shown in Table 8. Medium-small firms are prevailing in the *Star* category, thus revealing their particular vitality. The size classes composed of large and medium enterprises show, from the point of view of possible strategic interventions, opposite needs. The former would require incentives aimed at shrinking the firm size, while the latter would require actions to contain the use of inputs.

Table 8. Distribution of units by strategic category and size class
(percent)

Size class	LR Question Mark	Star	Dog	SR Question Mark
Large	49.70	20.18	14.46	15.66
Medium	14.48	28.12	15.83	41.57
Medium-small	28.55	38.48	14.18	18.79

7. Conclusions

This study represents an attempt to evaluate the efficiency of a set of Italian manufacturing firms with more than 50 employees, therefore not categorized as small businesses, in a DEA framework.

The decomposition of the overall efficiency into a managerial and scale factor highlights a limited impact of firm size and, simultaneously, notable differentials in terms of pure managerial performance. Such a decomposition assumes, however, a different configuration according to the size profile. In line with the literature, the study shows a good relative performance of medium-sized businesses, and especially of the medium-small firms class. In fact, in correspondence to this size level it is possible to observe the coexistence of an appropriate scale and virtuous managerial conditions (the latter, similar those observed for larger businesses). Furthermore, this class is associated with a higher labour compensation than that of large firms. This evidence suggests that the effort for the acquisition of high quality workforce has been rewarded by a greater innovation and management capacity, favoured by the characteristics of flexibility typical of small businesses. Moreover, a higher labour price should be able to create the conditions for a more careful use of this input. The by-input disaggregation of managerial performance supports this assertion, by indicating for the medium-small class a lower over-use coefficient. The same class, moreover, presents the greatest rate of short-term debt. Although this result looks very preliminary, it is interesting to note that the disciplining effect of

short-term debt may have contributed to the best performance of medium-small firms.

From a strategic point of view, the medium-small enterprises seem to benefit from the simultaneous presence of positive managerial and scale factors. In contrast, large and medium-sized enterprises appear to require different interventions in terms of favouring a scale reduction in the first case and improving operating processes in the second one. The competitive challenge involves the identification of incentive tools suitable to address these different scenarios.

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