CORPORATE BOARD AND FIRM PERFORMANCE: A DATA ENVELOPMENT ANALYSIS (DEA) OF ITALIAN LISTED COMPANIES

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Abstract

This study aims to examine the effectiveness of corporate governance mechanisms by analysing the influence of corporate board structure on firm performance. A sample of 224 non-financial publicly traded Italian firms is selected to test the proposed research hypotheses and evaluate the firm's efficiency by adopting a data envelopment analysis (DEA) approach. The findings show that corporate governance mechanisms are crucial in the performance of Italian publicly listed firms. The results show that the inclines and declines in DEA efficiency rankings are associated with the characteristics of the corporate boards. Additionally, many firms show a sub-optimal level of efficiency, as they do not operate at an optimal scale with respect to the efficiency frontier. This study represents an additional source of useful information for managers and stock investors because the DEA approach is a diagnostic tool for distinguishing between more and less efficient firms with respect to corporate governance mechanisms. This study contributes to the existing body of knowledge by providing a strategic framework to explore the board-performance relationship while applying the novel efficiency model.

Keywords: Corporate Governance, Firm Performance, Efficiency Frontier, Data Envelopment Analysis

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1. INTRODUCTION

Corporate governance (CG) is generally considered to be a fundamental system of settings that underpin a firm's performance and has attracted considerable interest from academics, economists, and politicians. The advantages of a strong governance framework are well-known and include better performance and efficiency, greater access to financing, lower cost of capital, and a more favorable approach to the management of stakeholders and their engagement (Claessens & Yurtoglu, 2013; Fu, Lin, & Molyneux, 2014). Conversely, poor governance mechanisms can increase risks by affecting the quality of firms' assets and are often related to a lack of

transparency (Adams & Mehran, 2012) and limited protection of minority shareholders' rights (Agyemang, Osei-Effah, Agyei, & Gatsi, 2019).

In recent years, investors have become ever more concerned about the role of CG mechanisms, especially in the wake of major corporate failures, including Enron and WorldCom in the US, and Ansett, OneTel, and HIH in Australia (Nasir, Ali, & Ahmed, 2019; Salim, Arjomandi, & Seufert, 2016). The main concerns relate to the agency dilemma that arises from the separation of ownership and control of firms. Therefore, an essential aspect of CG is the nature and extent of accountability of specific individuals in a firm and the mechanisms that mitigate or minimize the principal-agent problem (Bozec, Dia, & Bozec, 2010).

In the academic field, much effort has been devoted to the role of boards in the efficiency of firms as an argument in the agency theory (García-Sánchez, 2010); several studies have focused on the level of board effectiveness to mitigate the agency costs stemming from managerial self-interest, such as the effect of board size (Yermack, 1996), its independence (Hermalin & Weisbach, 1998), the efficacy of corporate boards (Agyemang et al., 2019), the ethnicity (Nasir et al., 2019), and activity (Vafeas, 1999); more recently, the issue of board gender diversity (BGD) has also gained considerable attention in the CG literature (Adams & Ferreira, 2009).

Prior literature has extensively examined the association between CG mechanisms and firm performance (Bhagat & Bolton, 2008; Ehikioya, 2009; Muhammad, Rehman, & Waqas, 2016; Lepore, Paolone, Pisano, & Alvino, 2017; Pillai & Al-Malkawi, 2018; Bhagat & Bolton, 2019; Muhammad, Migliori, & Mohsni, 2021). Indeed, these studies have significantly contributed to understanding the relationship between CG mechanisms and firm performance; however, the proposed explanations are only partial and sometimes lead to inconclusive results (Rossignoli, Lionzo, & Buchetti, 2020). A major limitation of these studies may be ascribed to methodology. Bhagat and Bolton (2008, 2019) argue that the previous empirical findings regarding the association between CG and firm performance are affected by endogeneity, which leads to inconsistent and biased regression estimates when simultaneous associations exist.

Given this still-open debate, this study aims at providing a further contribution by testing the degree of firms' performance against their corporate governance mechanisms, namely addressing the research question to what extent corporate board mechanisms affect firm performance according to a different level of efficiency.

Therefore, unlike previous studies, we use a non-parametric data envelopment approach (DEA) (Charnes, Cooper, & Rhodes, 1978) to re-examine the relationship between CG mechanisms and efficiency. We then test this new approach in the context of Italian publicly listed firms. In fact, we believe that the Italian governance mechanism has some distinctive features that differentiate it from the two leading CG mechanisms. These features include ownership concentration, the limited role of the financial market, and the prevalence of family business firms. Therefore, it is particularly important to understand whether and how CG mechanisms influence the performance of Italian publicly listed firms, as these mechanisms are the main drivers of CG best practices in Europe (Melis & Zattoni, 2017).

Our findings provide evidence that out of the 224 firms analyzed, nine are positioned on the efficiency frontier. Additionally, we verified that the number of firms with good efficiency scores was remarkably high. Thus, CG mechanisms are shown to be critical in determining the performance of Italian publicly listed firms, measured by profitability-based and market-based measures (ROA and Tobin's Q, respectively). We also verified that many firms did not operate at optimal scale and, therefore, their inefficiency also depended on scale factors.

We believe that this study may offer several contributions to the theoretical and empirical extant research on CG as well as to governance practices. First, our study contributes to the theoretical debate on the role and effectiveness of board characteristics in firm performance. Indeed, our study allows an evaluation of firms' board choices (in terms of size, independent directors, and gender diversity) with respect to an efficiency frontier, to establish the firms' positions relative to the frontier. Second, our study enriches the existing empirical studies on the relationship between board characteristics and firm performance by applying and extending the DEA approach to the context of Italian listed companies for the first time.

The remainder of the paper is structured as follows. In Section 2, we provide the literature review and hypotheses development. In Section 3, we describe the research methodology and explain how we selected the variables and indicators as validated by previous studies. Section 4 details the empirical results and analysis. Then, in Section 5, we provide a discussion of the main findings. Lastly, in Section 6, we draw some conclusions along with the managerial implications and limitations of the study.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The seminal work of Smith (1776) pioneered the concept of CG. Later, in the twentieth century, Berle and Means (1968) re-examined the concept and popularized it to the present era. According to the Corporate Governance Committee (1992), CG is defined as "… the system by which companies are directed and controlled" (p. 15). CG brings order to a firm and protects the benefits of all stakeholders. The aim of CG is to monitor and control structures to incentivize and motivate managers, minimize agency conflicts, and protect shareholder's rights.

In this context, agency theory is often used to elucidate the relationship between CG and firm performance. However, some studies have used the resource dependency theory to explain this association (Shin, Hyun, Oh, & Yang, 2018; Terjesen & Sealy, 2016).

Agency theory explains the separation of ownership and control between a firm's principals (owners) and agents (managers). In the relationship between owners and managers, the owners hire the managers to run the business in their best interests, compensating the latter for their services,

generally through salary and bonuses (Jensen & Meckling, 1976). According to agency theory, conflicts of interest can thrive in this association because of a divergence of the interests of managers and shareholders (managers may be rational but opportunistic). Because of this divergence, agency theory puts forward several propositions: 1) managers may pursue their benefit instead of maximizing shareholder value, 2) information is usually distributed asymmetrically between owners and managers, 3) contracts are expensive to write up and apply, and 4) both parties have limited or bounded rationality. Based on these propositions, the theory explains that, because of the information asymmetry between the managers and shareholders in a company, the owners cannot accurately measure the efforts of the managers, who know the operational details of the company. Thus, agency theory focuses on the effectiveness of boards. A board mitigates agency costs by monitoring and rewarding top executives to ensure the best interest of shareholders.

However, most agency theory empirical studies analyze Anglo-American listed firms (Yermack, 1996; Raheja, 2005), emerging and developing markets (Ehikioya, 2009), and selected European countries, such as Spain, Germany, France (Donadelli, Fasan, & Magnanelli, 2014; Bottenberg, Tuschke, & Flickinger, 2017). Nevertheless, little attention has been paid to Italy, despite its place as a large European economy with CG mechanisms that have some features in common with both archetypes in the existing literature (i.e., Anglo-Saxon and German-Japanese mechanisms).

Another perspective on the role of a board of directors in firm performance is proposed by the resource dependency theory (Pfeffer & Salancik, 1978). The perspective of the theory is more materialistic and less organization-centered. The theory mainly focuses on firms' access to resources, such as expertise and capital. Pfeffer and Salankcik (1978) argue that the resource dependency theory elucidates the structures of CG practices such as a board of directors, which affect a firm's access to relevant resources for firm performance. A board of directors is generally dominated by top management and therefore plays a vital role in strategy and in directing a firm. Kiel and Nicholson (2003) observe that a board of directors can provide supplementary networking and better access to resources that enhance a firm's performance. Thus, a board with diverse members has potential access to several external resources, which can enhance firm performance and value.

Therefore, for the purposes of this study, we consider a cohesive theoretical framework based on the agency and resource dependency theories to be appropriate for examining the relationship between CG and firm performance.

2.1. Board size and firm performance

Extant literature suggests that board size plays a crucial role in the effective governance mechanism of a firm (Lipton & Lorsch, 1992; Jensen, 1993; Raheja, 2005). The issue of the board and its size has received considerable attention from scholars and practitioners since it plays a key role in firm success and growth. The pioneering studies by Lipton and Lorsch (1992) and Jensen (1993) suggest that an effective board is essential for the success of a firm and that a board represents the relationship between managers and investors. Pearce and Zahra (1992) define a board as a mixture of human capital, where every board member has a particular set of skills and is ready to obtain more knowledge and expertise through further education and experience. On the other hand, board size refers to the total number of directors on a corporate board. Indeed, board size varies in different countries and firms because of diverse cultures, rules, and ownership structures (Adams & Mehran, 2005).

Prior studies argue the importance of both larger and smaller board sizes and propose contradictory results. For instance, Coles, Daniel, and Naveen (2008) postulate that larger boards should be beneficial to firms' growth and efficiency because more members on corporate boards can provide additional skills, extensive networking, and increased monitoring skills. In disagreement, some researchers argue that firms with larger board sizes face more difficulties and reduced firm efficiency due to coordination and communication issues (Dong, Girardone, & Kuo, 2017; Bennedsen, Kongsted, & Nielsen, 2008; Hamadi & Heinen, 2015). On the other hand, smaller boards communicate more effectively to serve shareholders' interests. A smaller board size reduces the risks of conflict and disagreement among board members. Likewise, Jensen (1993) argues that issues such as coordination and communication, flexibility in decision making, and control render larger boards less effective than smaller boards. This argument is supported by Yermack (1996) and Eisenberg, Sundgren, and Wells (1998).

Despite the theoretical arguments, the empirical results are also mixed and contradictory. The results range from positive, negative, to inconsistent. For instance, Adeabah, Gyeke-Dako, and Andoh (2019) use DEA to examine the association between CG practices and efficiency from 2009 to 2017. They find a positive and significant association between board size and firm efficiency. Similarly, Karbhari, Muye, Hassan, and Elnahass (2018) investigate the relationship between CG mechanisms and the efficiency of insurance (known as Takaful in the Islamic context) firms in 21 countries from 2002 to 2013. Using DEA, they show that board size and other CG components have a positive and significant influence on a firm's technical efficiency. Salim et al. (2016) also used the DEA to examine the association between CG practices and the efficiency of Australian banks from 1999 to 2013. Of the five CG components considered, they found that board size had a robustly significant and positive influence on efficiency. Through an OLS regression model, instead, Harymawan, Nasih, and Nowland (2020) provided evidence that firm performance is also positively related to board size, firm size, market-to-book ratio, and the number of committee meetings.

On the other hand, several studies find a negative association between board size and firm performance (De Andres, Azofra, & Lopez, 2005; Haniffa & Hudaib, 2006; Pathan & Faff, 2013). They show that this negative effect results from increased agency conflicts as the number of directors increases, leading to less effective management

control. Similarly, the agency theory affirms that a larger board size increases issues in communication and coordination, and therefore decreases a board's ability to control management. More recently, Nguyen, Rahman, Tong, and Zhao (2016) examine the effect of board size on firm performance in Australian firms from 2001 to 2011. They find strong evidence of a negative association between board size and firm value. However, some studies find no association between board size and firm performance (Monks & Minow, 1995; Bhagat & Black, 2002). Based on the discussion above, we propose the following hypothesis:

H1: There is a significant relationship between board size and firm performance.

2.2. Board independence and firm performance

Generally, external directors are considered as board members without any professional or personal connections with the firm (Zahra, Neubaum, & Huse, 2000). External directors can be divided into two groups: *affiliated* and *independent* external directors. Affiliated external directors are those who have consulting or other business associations with a firm (such as consultants, investment bankers, attorneys, and business partners), whereas independent external directors are those without such association with the firm, except their jobs as independent directors (Lawrence & Stapledon, 1999). Indeed, affiliated external directors may be unwilling to disagree with management decisions for fear of losing their directorships or jobs, and may have an incentive to uphold their association at the potential expense of shareholders' wealth (Byrd & Hickman, 1992). However, in this study, we focus on the independent external directors rather than the affiliated. Independent external directors play an essential role in measuring the effectiveness of board monitoring and add value to firms in their fiduciary responsibilities (Jensen & Meckling, 1976). They can work freely and are not subject to control or influence from major shareholders, management, or other relevant parties. Fama and Jensen (1983) postulate that independent external directors have more motivation to build up and improve their reputations by providing effective monitoring. Despite the potential benefits of independent external directors, however, some researchers believe that internal directors are more reliable and effective in the decision-making process. Indeed, internal directors possess firm-specific information that leads to effective decision-making and evaluation of top managers (Baysinger & Hoskisson, 1990). External directors are usually part-time and may sit on several other boards, and may therefore find it difficult to understand the complexities of a firm.

Over the past decades, a consistent number of contributions have been actively concerned with assessing the association between board independence and firm performance; however, there has been no consensus among scholars to date. For instance, Dong et al. (2017) examine the relationship between CG features and the efficiency of Chinese banking sectors during the period of 2003–2011. They find that board characteristics have a greater impact on the efficiency of the Chinese banking industry. They further show that board independence is positively associated with the banks' efficiency. Similarly, Dahya, Golubov, Petmezas, and Travlos (2019) investigate the relationship between external directors and the performance of UK acquirer firms. They postulate that increases in external director representation are related to better acquirer returns in deals, including listed firms, but not when a firm is private. Merendino and Melville (2019) use a dynamic generalized method of moments on a sample of Italian listed firms from 2003 to 2015 and examine the influence of CG practices on firm performance. The authors contend that firm performance does not necessarily improve with a higher number of independent directors; instead, a more balanced composition of the board is found to be beneficial. They, therefore, find a positive effect of lower levels of independent directorship on firm performance and negative effects of higher levels.

On the other hand, Sanan, Jaisinghani, and Yadav (2019) use a sample of 209 Indian listed firms from 2007–2016 and examine whether, in emerging markets, the association between CG and firm performance is related to firms' affiliation to a business group. They show that having more independent directors on a corporate board negatively impacts firm performance. They further find that, in group affiliated firms, independent directors do not affect firm performance. Similarly, Harymawan et al. (2020) analyzed a sample of all public companies listed on the Indonesian Stock Exchange during 2010–2017 and provided evidence that more independent boards are associated with lower firm performance.

Moreover, using DEA, Adeabah et al. (2019) examine the association between CG practices and the efficiency of 21 banks from 2009 to 2017. They reveal a negative and significant association between the number of independent directors and the banks' efficiency. Furthermore, some studies find that the presence of independent directors on a board does not improve firm efficiency. Similarly, Karbhari et al. (2018) and Terjesen, Couto, and Francisco (2016) analyze the relationship between the proportion of board independent directors and firm efficiency. Using an extensive dataset of 3876 firms from 47 countries, they find that external independent directors do not contribute to firm performance unless a board is a gender diversified. Based on the discussion above, we propose our next hypothesis as follows:

H2: There is a significant association between board independence and firm performance.

2.3. Board gender diversity and firm performance

Prior studies confirm that board composition affects firm performance (Carter, D'Souza, Simkins, & Simpson, 2010). One feature of board composition is gender diversity. BGD is increasing significantly, evidenced by a considerable improvement in female representation on corporate boards. In recent years, the relationship between BGD and firm performance has become a subject of intense debate among regulators, policymakers, shareholders, and corporate executives (Parola, Ellis, & Golden, 2015). This debate has encouraged countries to introduce mandatory gender quotas for corporate boards; for

instance, as of 2003, the Norwegian government requires corporate boards in publicly listed firms to be at least 40% female (Ahern & Dittmar, 2012; Eckbo, Makaew, & Thorburn, 2018). Mandatory quotas were also introduced in the US in 2009, in Iceland in 2010, in Italy, France, and Belgium in 2011, and Germany in 2015. Voluntary quotas were also introduced in Spain in 2007, and in the Netherlands in 2009.

Empirical evidence suggests that the impact of BGD on firm performance remains inconclusive. For example, Agyemang-Mintah and Schadewitz (2019) use a sample of 63 UK financial firms and examine the impact of BGD on firm performance for 12 years. First, they investigate whether the appointment of females on the corporate boards has an impact on the firms' value. Second, they investigated whether the presence of females on the boards influenced the firms' value during the pre- and post-global financial crisis periods. The results indicated that, during the pre-crisis period, female directors had a positive and significant impact on the firms' value. However, in the post-financial crisis period, the presence of females on the boards had no significant influence on the firms' performance. Overall, they find that female directors on corporate boards can improve firms' value. Similarly, Duppati, Rao, Matlani, Scrimgeour, and Patnaik (2019) conduct a comparative analysis between Singapore and India and examine whether female directors on boards are an effective driver of a firm's performance. Based on the stewardship and resource dependency theory, their results reveal that the presence of female directors on the boards of the firms in both countries has a positive and significant influence on the firms' performance. Furthermore, Papangkorn, Chatjuthamard, Jiraporn, and Chueykamhang (2019) investigated the role of female directors in the performance of 1,951 firms during the period 1997–2014. The authors examined the effect of female directors on the firms' value during the pre- and post-financial crisis periods. Consistent with the prior studies, they revealed that, during the pre-crisis period, the presence of female directors on the corporate boards significantly improved the firms' performance. However, such an impact was not found in the post-worldwide financial crisis period.

Meanwhile, Shehata, Salhin, and El-Helaly (2017) use a large sample of 34,798 UK small and medium-sized enterprises (SMEs) from 2005 to 2013 and investigate the association between BGD and firm performance. The results reveal a negative and significant association between BGD and firm performance. Similarly, Yang, Riepe, Moser, Pull, and Terjesen (2019) use a Norwegian legislative setting and examine the association between BGD and firm performance. The authors further use control group firms from Finland, Sweden, and Denmark. The results suggest that the mandatory appointment of female directors to boards has a negative and significant influence on firm performance.

Drawing on a sample of 6,365 firm-year observations based on the US S&P 1500 firms' data for the period 2010–2015, Benjamin and Biswas (2019) provided evidence that in firms with CEO duality, board gender composition positively impacts both a firm's propensity to pay dividends and the level of payouts.

Furthermore, Marinova, Plantenga, and Remery (2016) use a case of 186 listed firms in the Netherlands and Denmark in 2007 and investigate the impact of female directors on firm performance. Using the two-stage least-squares estimation method, the authors find no significant association between BGD and firm performance. Similarly, Unite, Sullivan, and Shi (2019) use a sample of an unbalanced panel of 2,648 firm-year observations during the period of 2003–2014 and examine the impact of female directors on firm value. Based on an integrated theoretical framework (i.e., agency theory, social psychology theory, and investor bias theory), the results imply that increasing the presence of females on corporate boards has no discernible influence on firm performance. Based on the above diverse studies, which provide inconsistent findings regarding the association between BGD and firm performance, we consider it necessary to re-examine this association. We, therefore, propose the following hypothesis:

H3: There is a significant association between BGD and firm performance.

3. RESEARCH METHODOLOGY

3.1. Data collection

We employed a data set of Italian publicly-traded non-financial listed firms to examine the association between CG mechanisms and firm performance for the year 2016. We chose Italian publicly-traded listed firms, based on the assumption that public companies are more transparent, genuine, and proactive as their financial and non-financial data are generally subjected to audit assurance and market authorities' controls. Moreover, public companies tend to be particularly focused on market performance and to engage more with stakeholders as they are more responsive to the needs and expectations of the global community.

We used the Analisi Informatizzata delle Aziende Italiane (AIDA) database of Bureau Van Dijk to collect data for our selected variables. This database is a comprehensive platform that allows the research, consultation, analysis, and processing of economic, financial, personal data, and commercial information of all joint-stock firms operating in Italy. The AIDA database contains economic-financial information for large, medium, and small Italian companies. This database has increasingly been validated and widely used in the literature (Lepore et al., 2017). We collected data from AIDA on CG items — the size of the board of directors (board size), the percentage of external directors (external directors), the percentage of women directors on board (BGD) — and economic and financial items (i.e., return on assets (ROA) and Tobin's Q).

For data collection, the total population includes 345 Italian publicly-traded non-financial listed firms during the study period, from different regions and business sectors. Of the 345 non-financial listed firms, 95 firms were excluded from the sample as suggested by Giovannini (2010) in a similar analysis. In detail, we excluded from

the sample banks, insurance companies, and financial companies, as their governance is mainly defined by legal criteria and specific rules. We also, excluded municipal and privatized, formerly government-owned enterprises, as they present some specific governance mechanisms to safeguard the public interest. Lastly, we excluded foreign companies, as the purpose of this study is to investigate the efficiency frontier of corporate governance mechanisms of Italian companies. Subsequently, 26 firms were eliminated because of outliers. Efficiency results from the DEA method rely on the homogeneity assumption of the sample of firms to be analyzed, as DEA is susceptible to outliers in data. Thus, the final sample used in the analysis comprised 224 non-financial Italian listed firms, covering 13 different sectors such as energy and natural resources, health care, information technology, telecommunications, utilities, textile, retailing, pharmaceutical, beverage and tobacco, fashion, tourism, manufacturing and construction, and automotive. Table 1 shows the reduced and selected samples by sector.

Table 1. Sector wise distribution of firms

No.	*Sector*	*Total firms*	*Percentage*	*Sample firms*	*Percentage*
1	Energy and natural resources	34	9.86%	18	8.04%
2	Health care	27	7.83%	17	7.59%
3	Information technology	25	7.25%	16	7.14%
4	Telecommunications	15	4.35%	09	4.02%
5	Utilities	24	6.96%	17	7.59%
6	Textile	33	9.57%	22	9.82%
7	Retailing	29	8.41%	21	9.38%
8	Pharmaceutical	26	7.54%	15	6.70%
9	Beverage and tobacco	28	8.12%	17	7.59%
10	Fashion	27	7.83%	19	8.48%
11	Tourism	18	5.22%	15	6.70%
12	Manufacturing and construction	34	9.86%	23	10.27%
13	Automotive	25	7.25%	15	6.70%
	Total	345	100%	224	100%

3.2. Measurement of variables

The DEA approach does not provide any suggestion on the selection of the most appropriate input-output system to be used in an efficiency assessment. Hence, in the selection of the input-output setting, emphasis should be given to what is postulated by efficiency theory and what is indicated in the context under analysis (Agovino & Rapposelli, 2013).

In order to model the relative efficiency of a set of decision making units (DMUs) (represented in this work by 224 Italian publicly-traded non-financial listed firms), it is first necessary to define a production function that captures the key points of the process under analysis. The input/output set identified in the production process has strong implications for the subsequent performance measurement.

In this study, we consider firm performance as an output. Phung and Mishra (2016) indicate that the efficiency of a firm's operation is described by its performance. To examine firm performance, it is essential to determine and choose the best performance indicators. To analyze the effects of CG mechanisms on the performance of Italian publicly listed firms, this study uses ROA (Muhammad et al., 2016) and Tobin's Q (Wahba, 2014) as profitability-based and market-based measures, respectively. Moreover, Black, Love, and Rachinsky (2006) explain that ROA indicates how profitable a firm's assets are in creating revenues, while Tobin's Q shows the effect of CG practices on firm market performance.

As inputs, we consider CG mechanisms, as measured through board size, board independence, and BGD. Consistent with Bhagat and Bolton (2008), board size is measured by the number of all board directors (García Martín & Herrero, 2018; Ayman, El-Helaly, & Shehata, 2019), while board independence is measured by the ratio of the number of independent directors to the number of all directors (Core, Holthausen, & Larcker, 1999; Allegrini & Greco, 2011). We measure BGD by the percentage of female directors that sit on a corporate board (Ayman et al., 2019). The presence of female directors on corporate boards brings different insights and perspectives in problem-solving and enables a better understanding of the marketplace (Adams & Ferreira, 2009).

We must emphasize that a causal relationship between the two kinds of variables (inputs and outputs) is not presumed, as our aim is to verify the degree of firms' performance against their corporate governance mechanisms (Belu, 2009).

3.3. DEA method

As a linear programming technique, DEA was developed by Charnes, Cooper, and Rhodes (1978) and was known as the CCR model, from the initials of these authors. This frontier method provides a measure of the relative efficiency of a set of homogeneous operating units (called decision making units — DMUs), which use the same set of inputs to produce the same sets of outputs. DEA efficiency measurement is "relative": this means it is referred to a subset of efficient "best practice" DMUs which the remaining units are compared with. DEA can handle multiple inputs and outputs at the same time (Lehmann, Warning, & Weigand, 2004), as well as give information about peer units (reference set) for each inefficient unit and targets to achieve.

The DEA approach has broadly been utilized in efficiency measurement for assessing the performance of different entities, such as power plants and public power plants (Färe, Grosskopf, & Logan, 1985), public hospitals and non-profit hospitals (Grosskopf & Valdmanis, 1987), educational units (Smith & Mayston, 1987), waste services (Simões & Marques, 2012), banks (Berg,

Førsund, & Jansen, 1991; Lin, Lee, & Chiu, 2009), company robots (Cook, Johnston, & McCutcheon, 1992), product family mix selection for a semiconductor fabricator (Chung, Lee, Kang, & Lai, 2008), airlines (Sengupta, 1999; Barbot, Costa, & Sochirca, 2008; Barros & Peypoch, 2009; Rapposelli, 2012; Rapposelli & Za, 2020), mutual funds (Rubio, Kabir Hassan, & Jamil Merdad, 2012), and computational industries (Thore, Phillips, Ruefli, & Yue, 1996).

Consistently with the above studies, we use the DEA approach to examine the association between CG mechanisms and the performance of Italian publicly traded firms. The basic DEA models measure the technical efficiency of each unit included in a set of n DMUs (in our case, 224 Italian publicly listed firms) by estimating the maximum feasible expansion of its output levels (output-oriented model) or the maximum feasible contraction of its input levels (input-oriented model). For each DMU, the models provide an efficiency score, bounded between zero and one, and a subsequent ranking of the units in the sample analyzed. An efficiency score equal to 1 means that the unit evaluated is efficient relative to the other DMUs in the sample; otherwise, the unit is relatively inefficient.

In this study, we calculate the technical efficiency of each firm by implementing a DEA model which accounts for variable returns to scale (VRS) of activities. Additionally, we focus on the output orientation of the model, as we assume, in this context, that the efficiency of the production process consists in the generation of desirable outputs from inputs used. Hence, firms that produce less outputs than others with the same input levels are relatively inefficient (Peda, Grossi, & Liik, 2013). We use the following formulation, introduced by Banker, Charnes, and Cooper (1984), known as the BCC model:

$$e_0 = max\phi_0 \quad (1)$$

subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{ij0} \quad (2)$$

$$\phi_0 y_{rj0} - \sum_{j=1}^{n} \lambda_j y_{rj} \leq 0 \quad (3)$$

$$\sum_{i=1}^{n} \lambda_j = 1 \quad (4)$$

$$\lambda_j \geq 0 \quad (5)$$

where, $y_{rj}$is the amount of the r-th output ($r = 1, \ldots, s$) for unit j ($j = 1, \ldots, n$), x_{ij} is the amount of the i-th input ($i = 1, \ldots, m$) for unit j, λ_j are the weights of units j, and ϕ_0 is the scalar expansion factor for DMU j_0 analyzed.

4. RESEARCH RESULTS

The DEA was performed using the Stata software. We have computed a set of scores for output-specific DEA efficiency at the firm level. The efficiency scores for each firm evaluated are shown in Appendix A; the descriptive statistics of the DEA efficiency scores are presented in Table 2.

In addition to the output-oriented DEA efficiency scores obtained from the BCC model (which accounts for VRS), we list the results of the CCR model (which accounts for constant returns to scale, CRS) conducted on the same data, as a comparison of the BCC and CCR scores provides additional information about inefficiency causes. The divergence of the CRS and VRS efficiency scores for a specific unit captures the impact of scale size on the unit's performance. It is well known that the BCC model estimates the pure technical efficiency score, devoid of scale efficiencies effects; hence, dividing the efficiency score obtained from the CCR model (a composite efficiency score that can be decomposed into scale efficiency and pure technical efficiency) by the score obtained from the BCC model yields a measure of scale efficiency for each firm (Banker et al., 1984).

The evaluation of the Italian listed firms by means of the BCC model shows that there are nine efficient firms (scoring VRS 1): K.R.Energy, Enervit, Wiit, PLC, Finlogic, Pharmanutra, Mondo TV, Cover 50, and Technical Public Service. Furthermore, six firms (Esautomotion, Fervi, Alfio Bardolla Training Group, Biodue, B&C Speakers, Italeaf) are quite close to the best practice frontier (VRS equal to or higher than 0.95), while 107 firms obtain an efficiency score bounded between 0.80 and 0.99. The remaining DMUs obtain quite high ratings, except for four firms that show low ratings (Netweek, Itway, Nova Re, and Olidata), with efficiency VRS score values lower than 0.60 (Appendix A, columns 2 and 7). The average level of pure technical efficiency is equal to 0.8135 (Table 3, column 3). These results suggest that Italian publicly listed firms operate at a high level of efficiency under the VRS assumption.

Based on these efficiency values, we classified the firms analyzed into two groups based on their characteristics. Focusing on the best performers (15 firms — above mentioned — with an efficiency score higher than 0.95), we cannot deduce the existence of a linear and consistent behavior based on the three selected CG variables, as may be noted from the following distributions (Tables 2a, 2b, and 2c):

Table 2a. Board size and BCC-efficient firms

Board size	*No. efficient firms*
2	1
3	3
4	2
5	5
6	1
7	2
8	1
Total	**15**

Table 2b. Board independence and BCC-efficient firms

Board independence	*No. efficient firms*
0	6
1	4
2	3
3	2
Total	**15**

Table 2c. Board gender diversity and BCC-efficient firms

Board gender diversity	*No. efficient firms*
0	7
1	4
2	2
3	2
Total	**15**

Similarly, we find the same distributions when we analyze the ten units located at the bottom of the rankings (firms with an efficiency score lower than 0.70).

Moreover, we compare the above rankings with managerial ownership, i.e., the proportion of shares owned by board members. We observe that the group of top performers is characterized by a high proportion of shares owned by board members; in contrast, many firms register a value equal to zero in the worst-performing group.

Finally, we control for a firm-specific variable, financial leverage, measured by dividing total debt by total assets (Jiraporn & Gleason, 2007). We note low values of this variable for the top-ranking group of firms and high values for the group of worst performers.

Focusing on the efficiency scores obtained from the CCR model, we observe more inefficient units and fewer efficient firms than in the BCC model; only three firms are fully efficient (K.R.Energy, Wiit, and PLC), and most DMUs show extremely low ratings (Appendix A, columns 3 and 8). The average level of CRS technical efficiency is equal to 0.2538 (Table 3, column 2).

Table 3. Descriptive statistics for BCC and CCR efficiency scores

	CCR efficiency scores	*BCC efficiency scores*
No. of efficient DMUs	3	9
Average	0.2538	0.8135
Maximum	1	1
Minimum	0.0033	0.0067
Standard deviation	0.1438	0.0923

We note that the BCC efficiency scores are much higher than the CCR scores. The observed divergence of the CRS and VRS efficiency scores suggests that many Italians publicly listed firms do not operate at an optimal scale, as it is well known that the CCR model produces efficiency values that are confounded by scale effects (compared to the BCC model that estimates pure technical efficiency at a given scale of operation for each unit).

Therefore, to investigate the difference between the actual scale of firms and their optimal scale, we compute the scale efficiency score for each unit analyzed. Our results show that only three firms register a scale efficiency equal to 1 and, therefore, operate at an optimal size, or most productive scale size (MPSS) (Banker et al., 1984). The remaining units are scale inefficient and register quite low ratings, except for seven firms that show efficiency values higher than 0.60 (Appendix A, columns 4 and 9). Almost all the firms considered do not operate at the MPSS; consequently, we argue that their inefficiency also depends on scale factors. On average, the scale efficiency score (equal to 0.3075) is higher than the CCR one and lower than the BCC one, whereas the score variability is lower (Table 4).

Table 4. Descriptive statistics for scale efficiency score

	Scale efficiency
No. of efficient DMUs	3
Average	0.3075
Maximum	1
Minimum	0.0893
Standard deviation	0.1472

Moreover, we investigated the nature of the scale inefficiencies for each unit, to establish whether returns to scale were increasing[1] or decreasing[2]. For this purpose, we ran an additional DEA program under the assumption of non-increasing returns to scale (NIRS) and compared the NIRS and VRS efficiency scores for each firm. If the two efficiency scores (NIRS and VRS) were different, it would mean there were increasing returns to scale (IRS) for the unit considered, whilst if the scores were equal, there would be decreasing returns to scale (DRS). Our findings show that 43 firms operate in an area of DRS, whilst 178 firms operate in an area of IRS (Appendix A, columns 5 and 10).

5. DISCUSSION OF THE RESULTS

We note that many Italians publicly listed firms do not operate at an optimal scale and the nature of the scale inefficiencies is mainly related to increasing returns to scale.

It is well known that, in the presence of DRS, a firm can increase its efficiency by reducing its production scale; conversely, when IRS is present, a firm should operate on a larger scale to increase its efficiency. Hence, most firms (about 80%) operate below their optimal scale: this means that their efficiency can be improved by increasing all the inputs (represented by the three corporate governance variables, i.e., board size, board independence, and BGD), as all the resulting outputs (ROA and Tobin's Q) will be disproportionately higher. Based on this evidence, we suggest some practical recommendations: to overcome the problems related to inadequate size and become fully efficient in terms of scale, these firms should increase the number of directors on the board (board size), the ratio of the number of independent directors to the total number of directors (board independence), and the proportion of female directors on the board (BGD).

Finally, we can state that there are certain problems related to inadequate CG mechanisms for some firms; however, greater efficiency gains can be achieved by increasing the inputs that, in our study, are represented by the three CG mechanisms measured through board size, board independence, and BGD.

6. CONCLUSION

In this study, we evaluated the performance of Italian publicly traded firms in the year 2016 with respect to their CG mechanisms (measured by some

[1] If an increase in all the inputs by 1% leads to an increase in all the outputs by more than 1%, we say that the frontier at this point exhibits increasing returns to scale (IRS).

[2] If an increase in all the inputs by 1% leads to an increase in all the outputs by less than 1%, the frontier at this point exhibits decreasing returns to scale (DRS).

CG variables: board size, board independence, and board gender diversity) by means of a non-parametric approach to efficiency measurement, DEA. For this purpose, we obtained measures of technical efficiency from VRS and CRS production frontiers.

The results from the BCC DEA model, which measures managerial efficiency devoid of scale effects, show that out of the 224 firms analyzed, nine are positioned on the efficiency frontier. Additionally, we verified that the number of firms with good efficiency scores was remarkably high. Thus, through DEA, CG mechanisms are shown to be critical in determining the performance of Italian publicly listed firms, measured by profitability-based and market-based measures (ROA and Tobin's Q, respectively).

Additionally, our findings provide evidence that many firms become more efficient when the CRS assumption is shifted to VRS; hence, in the second phase of our analysis, we investigated the impact of scale on unit performance by introducing, for each evaluated firm, a measure of scale efficiency. We verified that many firms did not operate at optimal scale and, therefore, their inefficiency also depended on scale factors. More specifically, about 80% of the firms considered operated below their optimal scale; consequently, we recommend a scaling up of their operations for optimal efficiency.

The present study represents an additional source of useful information for managers and stock investors; DEA was used as a diagnostic tool for distinguishing between more and less efficient firms with respect to three CG mechanisms, represented by the CG variables of board size, board independence, and BGD.

We believe that this study could contribute to the lively debate about the relevance of CG mechanisms in respect of companies' performance by providing evidence of the association between these mechanisms, as well as scale factors, and performance. Although many studies have explored the effect of board size and the presence of independent directors and females on a board on a firm's performance, the debate develops to find the best dimension for these governance variables with respect to performance results: how do firms balance the optimal use of these governance choices relative to the levels of performance that can be achieved through them? Our study provides a closer examination of these issues by considering the governance choices of board structure and composition as resources (input) that should be measured and balanced with a view to their efficient use with respect to the performance levels obtained (output). From this perspective, the choice of board size and the inclusion of independent directors and women on a board can be based on an evaluation of their potential impact on efficiency and effectiveness, rather than on a mere application of general rules of good governance practices.

Specifically, our study allows an evaluation of board choices (in terms of size, independence of directors, and gender diversity) against an efficiency frontier to determine the companies' positions relative to the frontier. Moreover, our study highlights how the DEA method can facilitate better interpretation of previous studies' findings by complementing the traditional and more widespread regression analyses. Finally, a practical implication for companies is the incentive for stricter adherence to good corporate governance practices. Indeed, our findings corroborate a relationship of technical efficiency between the extent to which a company adheres to good governance practices (inputs) and its achievable performance (output).

The study has limitations that suggest some avenues for future research. First, the usefulness of the method could be explored for larger data sets: for example, further studies on its application could compare and evaluate European firms. Second, the efficiency analysis applied in this work can be improved, from a dynamic and longitudinal perspective, by conducting a performance analysis over time.

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APPENDIX A. DEA efficiency scores — BCC and CCR models (Part 1)

Firm	*VRS*	*CRS*	*Scale*	*RTS*	*Firm*	*VRS*	*CRS*	*Scale*	*RTS*
Buzzi Unicem SpA	0.7841	0.1259	0.1605	irs	Bomi Italia SpA	0.7909	0.1734	0.2193	irs
Casa Damiani SpA	0.7920	0.2388	0.3016	irs	SOFTEC SpA	0.8077	0.2866	0.3548	irs
Elica SpA	0.7814	0.1714	0.2193	irs	Visibilia Editore SpA	0.8228	0.5874	0.7139	irs
Natuzzi SpA	0.7801	0.2688	0.3446	irs	Triboo SpA	0.7838	0.2692	0.3435	irs
Exprivia S.p.A.	0.8061	0.1945	0.2412	irs	COFIDE SpA	0.7887	0.1463	0.1855	irs
Freni Brembo SpA	0.8660	0.1491	0.1722	drs	CIR Compagnie Ind.li	0.7826	0.1348	0.1722	irs
Ambromobiliare SpA	0.8934	0.3180	0.3560	irs	Esautomotion SpA	0.9888	0.3408	0.3446	drs
Giorgio Fedon E/AZ SpA	0.8208	0.1642	0.2000	irs	Intek Group SpA	0.7842	0.1351	0.1723	irs
Poligrafici Editoriale S.P.A	0.7911	0.2386	0.3016	irs	Axélero SpA	0.9247	0.4951	0.5354	irs
IMA SpA	0.8385	0.1441	0.1719	drs	Media Lab SpA	0.8521	0.4044	0.4746	drs
IRCE S.p.A	0.8015	0.3199	0.3991	irs	DWC 3.0 S.p.A.	0.9117	0.6122	0.6715	irs
Aeroporto Marconi BO	0.8372	0.2507	0.2995	drs	Alfio Bardolla Training Gr.	0.9722	0.3859	0.3969	drs
Beghelli SpA	0.8818	0.2752	0.3121	irs	Enertronica SpA	0.7591	0.3030	0.3991	irs
Valsoia S.p.A.	0.8942	0.2690	0.3009	drs	Italiaonline SpA	0.8095	0.1302	0.1608	irs
HERA S.p.A	0.8059	0.1387	0.1721	irs	Finlogic SpA	1	0.7139	0.7139	drs
Datalogic S.p.A	0.7952	0.2127	0.2675	irs	Giglio Group SpA	0.8107	0.2794	0.3446	irs
Piquadro S.p.A.	0.8389	0.2530	0.3016	drs	Gequity SpA	0.7932	0.5663	0.7139	irs
BIO-ON S.p.A	0.8901	0.4765	0.5353	irs	Frendy Energy SpA	0.7839	0.1112	0.1418	irs
Cembre SpA	0.8833	0.2362	0.2675	drs	Caleffi SpA	0.8185	0.3266	0.3990	irs
Poligrafica San Faustino	0.8055	0.1288	0.1599	irs	CSP Intern. Fashion Group	0.7829	0.3720	0.4752	irs
Gefran S.p.A.	0.8028	0.2152	0.2680	irs	Immsi SpA	0.7893	0.1731	0.2193	irs
Sabaf SpA	0.8104	0.1500	0.1851	irs	Gr. Ceramiche Ricchetti	0.7715	0.2327	0.3016	irs
Bialetti Industrie S.p.A.	0.9195	0.4029	0.4381	drs	Fervi SpA	0.9806	0.4284	0.4369	drs
Saras SpA	0.9036	0.1452	0.1607	drs	Panaria Group Ceramiche	0.7957	0.2132	0.2679	irs
K.R.Energy SpA	1	1	1	-	Siti B&T Group SpA	0.8049	0.2771	0.3443	irs
Ratti S.p.A	0.9020	0.2196	0.2434	irs	PRISMI SpA	0.7642	0.3626	0.4745	irs
B&C Speakers S.p.A.	0.9583	0.2889	0.3015	drs	Autostrade Meridionali	0.8455	0.2869	0.3393	drs
El.En. SpA	0.8060	0.1768	0.2193	irs	Autogrill SpA	0.7802	0.0989	0.1268	irs
Rosss SpA	0.7871	0.2667	0.3389	irs	Portale Sardegna SpA	0.8673	0.3715	0.4284	irs
Biodue SpA	0.9701	0.5159	0.5318	drs	Carraro SpA	0.7971	0.2136	0.2680	irs
Centro HL Distribuzione	0.6800	0.1491	0.2193	irs	Safilo Group S.p.A.	0.7909	0.1585	0.2003	irs
EuKedos SpA	0.7716	0.3070	0.3979	irs	Carel Industries SpA	0.8721	0.3001	0.3441	drs
Sesa SpA	0.8087	0.2432	0.3008	irs	Brunello Cucinelli SpA	0.8876	0.1778	0.2003	drs
Toscana Aeroporti S.p.A	0.8285	0.1529	0.1845	irs	GO internet SpA	0.7354	0.2532	0.3444	irs
Tod's SpA	0.8465	0.1123	0.1326	drs	SMRE SpA	0.7980	0.3180	0.3985	irs
UniEuro SpA	0.9012	0.1969	0.2184	irs	Ecosuntek SpA	0.8427	0.2637	0.3130	irs
Trevi-Finanziaria Ind.le	0.7905	0.2119	0.2680	irs	Piaggio & C. SpA	0.7859	0.2105	0.2679	irs
Olidata S.p.A	0.0067	0.0033	0.4860	irs	Pharmanutra SpA	1	0.3446	0.3446	drs
Technogym S.p.A	0.8639	0.2316	0.2681	drs	Borgosesia SpA	0.7496	0.2260	0.3015	irs
PLT Energia S.p.A	0.8663	0.3796	0.4381	irs	Illa SpA	0.8260	0.2847	0.3446	irs
ERG S.p.A	0.7868	0.1265	0.1608	irs	Servizi Italia SpA	0.8185	0.1794	0.2191	irs
Ansaldo STS SpA	0.8172	0.2187	0.2677	irs	Biesse SpA	0.8492	0.2907	0.3423	drs
LVenture Group SpA	0.7351	0.1968	0.2677	irs	Rosetti Marino SpA	0.7852	0.1720	0.2190	irs
Netweek SpA	0.5925	0.2017	0.3404	irs	Emak SpA	0.7911	0.1272	0.1608	irs
Costamp Group SpA	0.9327	0.6659	0.7139	irs	Interpump Group SpA	0.8086	0.2153	0.2663	irs
Elettra Investimenti SpA	0.8011	0.3790	0.4731	irs	Iren SpA	0.7885	0.1117	0.1416	irs
SOL SpA	0.8010	0.1930	0.2409	irs	EEMS Italia SpA	0.7458	0.3546	0.4754	irs
Esprinet SpA	0.8056	0.1495	0.1856	irs	Caltagirone SpA	0.8702	0.1589	0.1826	irs
Ei Towers SpA	0.8350	0.2238	0.2680	drs	Leonardo SpA	0.7886	0.1454	0.1844	irs
ACSM-AGAM S.p.A	0.7750	0.1867	0.2409	irs	Astaldi SpA	0.8164	0.2188	0.2681	irs
Fintel Energia Group SpA	0.8597	0.3756	0.4369	irs	Cementir Holding SpA	0.7919	0.1466	0.1851	irs
Pirelli & C. SpA	0.7928	0.0953	0.1202	irs	AS Roma SpA	0.7978	0.0962	0.1206	irs
FNM S.p.A	0.8071	0.2781	0.3446	irs	SS Lazio SpA	0.7544	0.3009	0.3989	irs
Bastogi SpA	0.7824	0.2095	0.2678	irs	Vianini SpA	0.7837	0.1454	0.1855	irs
SAES Getters SpA	0.7715	0.1031	0.1336	irs	Mondo Tv SpA	1	0.4369	0.4369	drs
Italmobiliare SpA	0.8091	0.1023	0.1264	irs	Sintesi Soc. Invest. Prtcpzn	0.6681	0.2015	0.3016	irs
Recordati SpA	0.8309	0.1178	0.1417	drs	Leone Film Group SpA	0.8005	0.2759	0.3446	irs
Vincenzo Zucchi SpA	0.7859	0.2708	0.3446	irs	Telesia SpA	0.8207	0.3269	0.3983	irs
Salini Impregilo SpA	0.8153	0.1156	0.1418	irs	TAS Tecn. Avanz. Sistemi	0.7602	0.2036	0.2678	irs
Il Sole 24 Ore SpA	0.6206	0.1360	0.2191	irs	Eni SpA	0.7796	0.1706	0.2188	irs
Saipem SpA	0.7740	0.2062	0.2663	irs	Beni Stabili SpA Soc.di Inv	0.8051	0.1942	0.2412	irs
Amplifon SpA	0.8152	0.1639	0.2010	irs	ACEA SpA	0.7941	0.2106	0.2653	irs

APPENDIX A. DEA efficiency scores — BCC and CCR models (Part 2)

Firm	*VRS*	*CRS*	*Scale*	*RTS*	*Firm*	*VRS*	*CRS*	*Scale*	*RTS*
Davide Campari-Milano	0.8262	0.1812	0.2193	irs	Lucisano MEDGR/AZ SVN	0.7936	0.3161	0.3983	irs
Cairo Communication SpA	0.7890	0.1586	0.2010	irs	Terna	0.8288	0.2222	0.2681	irs
A. Mondadori Editore SpA	0.7807	0.1345	0.1723	irs	Rai Way SpA	0.9061	0.2424	0.2675	drs
Class Editori SpA	0.7599	0.1146	0.1508	irs	Caltagirone Editore SpA	0.7887	0.1585	0.2009	irs
Gas Plus SpA	0.7869	0.2711	0.3445	irs	Gambero Rosso/AZ SVN	0.8020	0.2762	0.3444	irs
Mediaset SpA	0.7865	0.1114	0.1417	irs	Enav SpA	0.8275	0.2211	0.2672	irs
FullSix SpA	0.8097	0.25342	0.312962	irs	Atlantia SpA	0.7914	0.1463	0.1849	irs
Isagro SpA	0.7939	0.2394	0.3015	irs	Be Think Solve Execute SpA	0.7716	0.2068	0.2680	irs
Digital Bros S.p.A.	0.7615	0.2038	0.2677	irs	Maire Tecnimont SpA	0.8033	0.1938	0.2412	irs
Sec SpA	0.7605	0.2421	0.3184	irs	Imvest SpA	0.7347	0.3477	0.4732	irs
TXT e-solutions SpA	0.8354	0.1827	0.2188	drs	Notorius Pictor/AZ SVN	0.9057	0.3879	0.4284	irs
I Grandi Viaggi SpA	0.8802	0.2755	0.3130	irs	Nova Re SpA	0.4504	0.1199	0.2662	irs
Prada S.p.A.	0.8609	0.2067	0.2401	drs	Aeffe S.p.A.	0.8010	0.2415	0.3015	irs
Mediacontech S.P.A.	0.7782	0.4138	0.5318	irs	Marr SpA	0.8505	0.2274	0.2674	drs
Tesmec SpA	0.8027	0.2421	0.3016	irs	Indel B SpA	0.9101	0.2181	0.2396	drs
Tamburi Invest. Partners	0.7745	0.2074	0.2678	irs	La Doria SpA	0.8262	0.2209	0.2674	irs
Ambienthesis SpA	0.7996	0.2714	0.3394	irs	GPI SpA	0.9147	0.2854	0.3121	irs
Blue Fin. Communication	0.8923	0.4778	0.5354	irs	Expert System SpA	0.7762	0.2341	0.3016	irs
Molecular Medicine SpA	0.6650	0.1457	0.2191	irs	ASTM SpA	0.7884	0.1267	0.1607	irs
A2A SpA	0.7825	0.0858	0.1096	irs	Juventus Football Club SpA	0.7997	0.1286	0.1608	irs
Rizzoli CorriereS Mediagrp	0.7909	0.1590	0.2010	irs	Centrale del Latte d'Italia	0.7894	0.2111	0.2674	irs
Enervit SpA	1	0.4087	0.4087	drs	Prima Industrie SpA	0.8106	0.1488	0.1836	irs
Itway SpA	0.4806	0.2280	0.4745	irs	Ki Group SpA	0.8774	0.3024	0.3446	drs
Telecom Italia SpA	0.8220	0.0734	0.0893	irs	Fidia SpA	0.8024	0.2147	0.2676	irs
Snaitech SpA	0.8286	0.1249	0.1507	irs	Reply SpA	0.7910	0.2118	0.2678	irs
Risanamento SpA	0.9246	0.3779	0.4087	irs	Societa Iniz. Autostr. e Servi	0.7890	0.2114	0.2680	irs
Reti Telematiche Italiane	0.7794	0.1174	0.1506	irs	Cover 50 SpA	1	0.4381	0.4381	drs
Casta Diva Group SpA	0.8296	0.4439	0.5352	irs	Italia Independent Group	0.7672	0.2750	0.3584	irs
WM Capital SpA	0.7715	0.3667	0.4754	irs	TerniEnergia SpA	0.7826	0.2357	0.3011	irs
Fiera Milano SpA	0.7486	0.1061	0.1417	irs	Vetrya SpA	0.8274	0.3303	0.3991	irs
Snam SpA	0.7911	0.2116	0.2674	irs	Italeaf SpA	0.9519	0.6548	0.6879	irs
Openjobmetis SpA	0.8304	0.1668	0.2008	drs	Fincantieri SpA	0.7979	0.2139	0.2681	irs
Wiit SpA	1	1	1	-	Stefanel SPA	0.7369	0.1778	0.2412	irs
Falck Renewables SpA	0.7736	0.1242	0.1606	irs	Nice S.p.A.	0.8132	0.2452	0.3016	irs
Eprice SpA	0.7565	0.2028	0.2681	irs	Geox SpA	0.7947	0.1743	0.2193	irs
Newron Pharmaceuticals	0.6962	0.2179	0.3130	irs	Massimo Zanetti Beverage	0.7853	0.2099	0.2673	irs
Compagnia Imm. Azionaria	0.8409	0.1691	0.2010	drs	Ascopiave SpA	0.7834	0.2356	0.3007	irs
Alerion Clean Power SpA	0.7894	0.1356	0.1717	irs	H-Farm SpA	0.7108	0.2450	0.3446	irs
Digital Magics SpA	0.7854	0.1574	0.2004	irs	Somec SpA	0.8925	0.4214	0.4722	drs
PiteCo SpA	0.8683	0.2980	0.3432	drs	DBA Group SpA	0.7896	0.2714	0.3438	irs
MailUp SpA	0.7929	0.2125	0.2681	irs	Danieli & C Off. Meccaniche	0.7920	0.2386	0.3012	irs
Sogefi SpA	0.7860	0.1896	0.2412	irs	Eurotech SpA	0.7747	0.2077	0.2681	irs
Moncler SpA	0.9412	0.2058	0.2187	drs	Technical Public. Service	1	0.4754	0.4754	drs
Prysmian SpA	0.7816	0.1714	0.2193	irs	DiaSorin SpA	0.8793	0.1608	0.1829	drs
Parmalat SpA	0.8001	0.2138	0.2672	irs	Zignago Vetro SpA	0.8478	0.1704	0.2010	drs
Gruppo MutuiOnline SpA	0.7744	0.1557	0.2010	irs	Gruppo Green Power SpA	0.8136	0.3485	0.4284	irs
PLC SpA	1	1	1	-	SFA S.p.A	0.8933	0.3903	0.4369	irs
Biancamano SpA	0.7584	0.2033	0.2681	irs	Fope SpA	0.8312	0.2860	0.3440	drs
Alkemy SPA	0.8924	0.6371	0.7139	irs	CAD IT S.p.A.	0.7966	0.2745	0.3446	irs
DIGITOUCH SpA	0.7981	0.3186	0.3991	irs	Masi Agricola SpA	0.8383	0.2238	0.2669	drs

Note: RTS: returns to scale; IRS: increasing returns to scale; DRS: decreasing returns to scale.