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RESEARCH ARTICLE

The determinants of board size in Italian State-owned enterprises operating in water industry

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Abstract This study investigates what are the determinants of board size in Italian water State-owned enterprises. The analysis has been conducted on a sample of 105 Italian water State-owned enterprises. Furthermore, data for the year 2018 have been used to run an ordinary least squares statistical model. Most relevant findings suggest that the two ownership structure variables, expressed through the number of public owners and the degree of direct public ownership, are statistically and significantly related to board size. Specifically, the number of public owners is positively and significantly related to board size. Conversely, the degree of the direct public ownership is negatively and significantly related to board size. The investigation provides a contribution for academics and policy-makers. Given the essentiality of water resource for humanity and future generations, the study emphasizes the need to ensure the inclusion of citizens in Italian water SOEs' ownership and boardroom as a pragmatic and functional reality.

Keywords Board size · State-owned enterprises · Water industry · Ownership structure

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Introduction

Worldwide, local governments are increasingly creating and operating State-owned enterprises (SOEs) to provide services in several industries, such as the water resource (Voorn et al. 2018; Torsteinsen 2019). In Italy, the water industry has been characterized by a long process of reforms to enhance its efficiency (Lugaresi 2000; Romano and Guerrini 2014). Nevertheless, few studies investigated the relationship between corporate governance and the efficiency in Italian water SOEs (Lugareesi 2000; Pazzi et al. 2013; Romano and Guerrini 2014; Romano et al. 2015). Grossi and Thomasson (2011) suggest that some changes in corporate governance of Italian water SOEs, ought to be done. In the last decades, literature has well-recognized the crucial importance of corporate governance in SOEs (Edwards and Clough 2005; Bozec and Dia 2007; Bachiller 2009). Though, few studies have studied the corporate governance in Italian water SOEs (Menozzi et al 2011; Romano et al. 2013; Romano and Guerrini 2014). Scholars mainly investigated the role of directors (Farrell 2005; Calabrò et al. 2013; Romano et al. 2014; Federo et al. 2020). SOEs board are not randomly structured (Guest 2008; Linck 2008; Andrews 2022). One of the much-debated issues either in the academic (Jensen 1993; Hermalin and Weisbach 2003; Chen et al. 2008; Liang et al. 2013) or in the Italian normative (Law 178 of 2010 and Law 175 of 2016) concerns the choice of board size in SOEs. Given the significance of board

size, a body of literature has analysed its determinants[1] (Raheja 2005; Boone et al. 2007; Linck et al. 2008; Guest 2008; Menozzi et al. 2014; Andrews 2022). However, none of them have already investigated the determinants of board size in companies operating in Italian water industry. The article aims to answer the following research question: *what are the determinants of board size in the Italian water SOEs?* To conduct the investigation, it has been analysed a sample of 105 Italian majority/SOEs operating in the water sector. This study aims to enhance the academic literature on water utility management. Moreover, it contributes to the debate on corporate governance in local public utilities (Hodges et al. 1996). Then, the author answers the call for more specific research on public utilities governance mechanisms (Grossi and Reichard 2008; Farrell 2005). Finally, it answers to the request from other previous studies (Calabrò et al. 2013) for what concerns the need for future research investigating the "black box" of the Italian local public utilities' board of directors. This article provides a helpful contribution mainly for academics and policy-makers. The paper is organized as follows. The theoretical background is provided in Sect. "Theoretical background". Section "Research hypotheses development" is devoted to the research hypotheses development. The methodology is shown in Sect. "Methodology", while Sect. "Empirical findings" is dedicated to the empirical findings. Discussion and conclusion are given in Sect. "Discussion and conclusion".

Theoretical background

The main characteristics of corporate governance in Italian SOEs

The term "State-owned enterprises" is the most frequently used by academics and practitioners to define enterprises in which the central or local governments have significant control, through full, majority, or significant minority ownership (Aharoni 1981; Bruton et al. 2015). In Italy, the State ownership phenomenon is particularly relevant (Grossi and Reichard 2008). Italian SOEs are characterized by a high separation between the ultimate ownership (the citizens) and the control rights (the public owners) (Berle and Mens 1932). As a consequence, there are more complex agency problems (Allegrini and Greco 2013; Calabrò et al. 2013; Allini et al. 2016). The agency theory (Jensen and Meckling 1976) may be a powerful heuristic in explaining the behaviour of a board of directors (Miller-Millesen 2003). Prior studies (Calabrò et al. 2013; Allini et al. 2016) have considered the agency theory perspectives to investigate some corporate governance characteristics in Italian SOEs. Gnan et al. (2010, pg. 724) remark*: "Applying agency theory to SOEs, it can be noted that the owner-manager relationship is broken down into two other agency relationships (*Villalonga 1999*): (1) the relationship between citizens (the 'real' owners of SOEs) and the government (the 'formal' owner); (2) the relationship between the government (the 'formal' owner) and the managers of SOEs. Moreover in the cases in which some private investors are present in SOEs' ownership, an additional kind of agency relationship concerns the government (as control shareholder) and the minority shareholders" (*OECD 2005*).* Furthermore, compared to other countries, in Italian SOEs, the boards are typically characterized by the presence of politically connected directors (Menozzi et al. 2011; Giosi and Caiffa 2021). Indeed, in Italian SOEs' boards, government and board members are linked by a so-called "reciprocal opportunism" (Apriliyanti and Kristiansen 2019) since most board positions are assigned to bureaucrats and politicians interested in gaining political benefits rather than pursuing the public interest (Young et al. 2008; Dragomir et al. 2021). Despite all these main critical issues of corporate governance, in Italian SOEs, there are not forms of citizens' engagement in the board of directors, devoted to promote a democratic governance (Andrews 2022).

A typical sector managed by Italian SOEs: the water industry

The European Water Framework Directive (2000/60/EC) is based on the idea that water management needs to take account of social, ecological and economic issues and that its prime scope is the sustainable management and the use of water resources. Promoting an efficient management of water resources is helpful to reduce waste, allocate resources rationally

[1] See meta-analysis Dalton et al. 1999.

and limit negative effects on development (Lugaresi 2000). The Italian water industry has been characterized by a long process of reform with the purpose to enhance its efficiency. To achieve this scope, deep changes in the governance of water services took place. Originally, the supply of water was provided by several local public firms which were managed directly by the local municipalities. Most of them were very small in structure and size. A re-organization of the water sector started in 1994, with the Law n. 196 (the so-called Galli Law). Among other, this law established that the water services may be provided by public or mixed or private enterprises. The process of reform continued in 2002 with the Italian budget law. It identified three methods to assign the management of water supply: in-house entrustment, public tender and direct grant to a public–private company in which the private partner must be selected by a tender. Then, in 2006, the Italian Law n. 152 of 2006 established new water services standards, defining more specifically the activities and tasks for the several water industry's operators. In 2009, the Law 191 first established that water services had to be franchised to public–private utilities in which the private partner held at least 40% of the shareholdings. Secondly, it also established that water services could not be managed wholly by public partners after December 2011. Though, due to the increasing prices for water services, users started to complain about the reforms carried out over the years, stating that they generated a progressive transition from a public to a private interest focus (Massarutto 2011, 2015). This aspect has been emphasized in 2011 with a national referendum in which the Italian electorate rejected the proposal to privatize the water service. Moreover, given the importance of water as a fundamental public good for all European citizens, directive 2014/23/EU emphasized that the concessions concerning the water sector are often subject to specific and complex regimes which require special considerations, In addition, directive 2014/25/EU clearly establishes that none of the Member States are obliged to externalize the provision of water services, if they prefer to organize them in alternative ways (e.g. through the in-house companies).

Nowadays, water supply is generally managed through public ownership (Mellah and Ben Amor 2016). The public ownership of all the water resources has a dual value. On the one hand, it constitutes a matter of principle, ruling out the legal possibility of private ownership of natural resources that are indispensable for human life. On the other hand, it prevents the law of basic interests from being distracted by side issues (Lugaresi 2000). For some critical resources that involve public interests, as water resource, management and decisions should be taken not by a single owner, whether public or private, but through a process that is democratic and deliberative (Di Robilant 2014). Specifically, Di Robilant (2014) focuses on the role of citizens in generating new property forms that are later ratified by the policy-makers. Specifically, for what concern water resource, Di Robilant (2014, pg. 326) states that: *"Italy has spawned a vocal 'water movement' which has called for a new legal conceptualization of water beyond private or public ownership. Water implicates interests that go well beyond the short-term economic interest of human users and raises distributive questions. Potable water serves basic survival and health needs and, hence, should be equally accessible to all. Furthermore, water involves questions of stewardship and protection of the interests of future generations. Water also implicates fundamental non-human, ecological interests. These interests are not likely to be represented when water is governed through private property or public property. The concept of 'common goods' is being revived to provide an alternative to public and private ownership. Ownership of 'common goods' differs from public ownership in an important way because it gives citizens collectively not only use entitlements, but also the right to participate in management decisions"*. Though, the participation of citizens is still an occasional phenomenon in the Italian system (Lugaresi 2000).

Research hypotheses development

The relationship between the number of public owners and board size in Italian SOEs

According to the first paragraph of the current Italian civil code's article 2449, if the State or other public entities hold shares in a corporation that does not invest within the capital market, the Statute could empower them to appoint directors, in proportion to the piece of capital that they hold. An investigation conducted on a sample of Italian local public utilities

confirms that this regulatory provision has been well-accepted (Calabrò et al. 2013). Next, according to the second paragraph of the current Italian civil code's article 2449, the directors appointed by the first paragraph may only be removed from the public bodies that nominated them. The power of direct nomination and the power to revoke attributed to the public owners, de facto nullifies the board's ability to exercise an effective oversee function (Young et al 2008). In Italian SOEs, each public owner is more incentivised to pursue its self-own personal interests than the interest of citizens (the "real" owners) (Menozzi et al. 2011; Vining and Moore 2022). When more than one public owner controls SOEs, the board must "serve multiple masters" (Waterman and Meier 1998) since, according to the agency theory (Jensen and Meckling 1976; Fama 1980; Eisenhardt 1989), it is the "agent" of an increasingly heterogeneous group of public owners (Werner et al. 2005; Connelly et al. 2010; Desender et al. 2013). Each owner influences the business strategy through the pressures exercised on board members (Anderson et al. 2003). From agency theory, a plausible behavioural outcome is that directors focus their efforts on mediating over goals between the owners (Vining et al. 2014; Vining and Weimer 2016; Aguir and Misra 2017) and without considering the interests of all the citizens (the "real" owners) (Collin 2007; Su et al. 2008; Cornett et al. 2010; Dahya et al. 2008). This also happens in Italian water SOEs (Grossi and Thomassion 2015). In general, the extent of agency costs, arising from managerial discretion, increases in the number of owners and in the number of owners with different goals (Vining and Moore 2022). Indeed, the more public owners there are, the more there could be conflicting the interests and objectives that they wish to pursue (Gunasekhar and Dinesh 2017). Hence, SOEs with multiple public owners are likely to have larger boards (Andrews 2022). Conversely, a small number of public owners generates greater convergence in the interests of ownership, reducing the costs associated with achieving agreement about its strategic control (Jensen and Meckling 1976). Consequently, a smaller number of directors will be enough to ensure that the board effectively represents owners' interests (Kieschnick and Moussawi 2004).

For all above, it seems appropriate to formulate the following research hypothesis:

H_1 The number of public owners is positively associated with board size in Italian SOEs.

The relationship between the degree of public ownership and board size in Italian SOEs

The degree of public ownership concentration may assume values ranging between the two extreme 0 and 100% (Bel and Fageda 2010; Boardman and Moore 2020). In Italy, a typical sector of activity characterized by a higher public ownership concentration is the water sector (Utilitalia 2019). Ownership concentration has long been considered an effective external control mechanism to monitor the decisions and actions of management and to influence the board of directors (Haider and Fang 2016). Previous studies argue that the degree of ownership is associated with the board size (Kaplan and Minton 1994; Shleifer and Vishny 1986; Beiner et al. 2004; Kenneth et al. 2009; Allegrini and Greco 2013), finding a negative relationship between the degree of shareholdings held by the largest owner and board size (Yermack 1996; Barucci and Falini 2005). This inverse relationship is also verified in SOEs scenario (Munisi et al. 2014; Andrews 2022). Conforming to the agency theory (Jensen and Meckling 1976), concentrated ownership reduces the costs arising from the divergence among owners' interests and between the interests of owners and directors who control it (Aziz et al. 2015; Moez 2018). A higher public ownership concentration reduces the request for a larger board for the following main reasons. Public owners with the larger holdings will take more responsibility to monitor the managers (Shleifer and Vishny 1986; Mishra 2011; Munisi et al. 2014). Moreover, the need for an advisory role decreases in the presence of a higher concentrated public ownership (Guest 2008; Chen and Al-Najjar 2012; Munisi et al. 2014). Furthermore, majority public-owned SOEs are therefore likely to need fewer executive directors than minority public-owned SOEs where the latter experience higher transaction costs associated with bringing private and public actors together (Hoppe and Schmitz 2010).

We therefore hypothesize:

H_2 The degree of public ownership is negatively associated with board size in Italian SOEs.

The relationship between CEO duality and board size in Italian SOEs

CEO duality refers to the situation in which the Chairman is also the Chief Executive Officer (Baliga et al. 1996; Rechner and Dalton 1989). Generally, CEO duality takes place when the individual playing the role of CEO held this position for a long time (Quan et al. 2010) or in the case in which the supervision of shareholders is weak (Bebchuk and Fried 2005). Empirical evidence on the effects of CEO duality on board size is controversial (Linck et al. 2008; Boone et al. 2007; Guest 2008; Elsayed 2010). Moreover, few prior studies have examined how CEO duality in SOEs affects other corporate governance mechanism (Bozec and Dia 2007; Peng et al. 2007, 2010). The effects of CEO duality phenomenon on other corporate governance variables are context-specific (Tian and Lau 2001; Bozec and Dia 2007; Peng et al. 2007 2010; Elsayed 2011). Specifically, in SOEs, the CEO duality phenomenon is a double-edged sword. Indeed, its implications on corporate governance depend on the purposes to which the majority public owner has decided to give priority (Firth et al. 2014). Specifically, when the majority public ownerships want to pursue profit goals, the increased power linked to the CEO duality may give CEOs a greater capability to pursue the private interests, sacrificing the ownership value (Firth et al. 2014). Conversely, when the public majority owner wants to pursue non-profit goals, a CEO duality may be advantageous for the corporate governance in SOEs (Firth et al. 2014). According to the agency theory (Jensen and Meckling 1976), the roles of CEO and Chairman should be separated to exercise a more effective monitoring function (Judge et al. 2003) and to reduce agency costs (Yu and Ashton 2015). CEO duality vanishes de facto the board of directors' ability to monitor management's opportunistic behaviours (Boyd 1995; Finkelstein and D'Aveni 1994). CEO duality may detract from the board of directors' effectiveness by reflecting the relative power of the CEO in setting the board's agenda, controlling information flow, and weakening the independence of outside members (Boyd 1995; Brickley et al. 1997; Desai et al. 2003). When CEO duality occurs, the CEO will dominate the board (Daily and Dalton 1993, 1994); therefore, the board of directors' power decreases, while CEO power increases (Daily and Schwenk 1996). CEO power, in turn, may also significantly affect the board structure, including its size (Hermalin and Weisbach 2003).

Therefore, it seems appropriate to formulate the following research hypothesis:

H_3 CEO duality is negatively associated with board size in Italian SOEs.

The relationship between being an in-house company and board size in Italian SOEs

In Italy, the overall requirements that companies must have to be qualified as in-house companies are established by Law n. 50 of 2016. The in-house companies may be considered as a *"longa manus"* of the public ownership that have been constituted them (Tangi et al. 2021). Indeed, a true "inter-organic relationship" exists between the public partner and the juridical entity of the in-house company (Cisternino 2020). Formally, they are entities with distinct legal autonomy. Substantially, the public ownership exercises a real relationship of juridical subordination over them. Hence, the board of directors in the in-house companies is in a position of absolute hierarchical subordination (Cisternino 2020). As a consequence, its role is different in the in-house companies than the role that it assumes in other firms. Indeed, in the in-house companies, the public ownership has the statutory power to dictate the strategic decisions and operational choices (Cisternino 2020). Consequently, the board of directors of the in-house companies does not have significant management powers because the public ownership must exercise a wider power than usually Italian company law assigns to the majority partners (Gruner 2012; Cisternino 2020). Hence, the so-called "*controllo analogo*" does not allude to the dominant influence that the ownership is ordinarily able to exercise over the board of directors (Cisternino 2020). Conversely, it manifests itself as a true power of command that is directly exercised over the board of directors in a manner and intensity that is not attributable to the rights and faculties that generally accrue to the shareholders (Cisternino 2020). Hence, it is a power to control in which the company bodies are not entrusted with any significant management autonomy (Cisternino 2020).

For all above, it seems appropriate to formulate the following research hypothesis:

H_4 Being an in-house company is negatively associated with board size in Italian SOEs.

Methodology

The context of investigation

The hypotheses formulated in the prior section were tested on a sample of Italian water SOEs for the following main reasons. The companies operating in water industry represent a typical example of enterprises mainly owned by public owner/s (Mellah and Ben 2016; Utilitalia 2019). Therefore, the considerations presented in Sect. "The main characteristics of corporate governance in Italian SOEs" of this paper surely are relevant for companies operating in this sector of activity. Moreover, there are also other prior studies (Romano and Guerrini 2014; Poomdeeying 2019) that explicitly mentioned firms operating in water industry when investigating the main characteristics of board of directors in Italian SOEs. Furthermore, how Sect. "A typical sector managed by Italian SOEs: the water industry" emphasized, over time the water industry has been widely reformed by Italian regulator to improve its efficiency (Lugaresi 2000; Romano and Guerrini 2014). Though, Romano et al. (2015) find a negative relationship between board size and efficiency in Italian water utilities, without considering the factors affecting the board size. This is the first paper that analyses the determinants of board size on a sample of Italian water SOEs. Specifically, the Italian SOEs under investigation in this study have been selected following rigorous criteria presented in Table 1.

At the end of these steps above mentioned, the sample consisted of 105 Italian water SOEs.

Statistical model specification and description of statistical variables

A linear multiple regression model has been used to assess the contribution of independent variables in predicting board size of the 105 Italian water SOEs selected. Specifically, the following ordinary least squares (OLS[2]) statistical model has been developed:

$$\begin{aligned} \ln\_b_{\text{size}} = {} & \beta_0 + \beta_1 \text{Shares} + \beta_2 \ln_{\text{Public\_owners}} \\ & + \beta_3 \text{CEO}_{\text{Dual}} + \beta_4 \text{In}_{\text{house}} + \beta_5 \ln_{\text{Comp}_{\text{Size}}+1} \\ & + \beta_6 \text{islands} + \beta_7 + \beta_8 \text{north} + \beta_9 \text{south} \\ & + \beta_{10} \text{centre} + \varepsilon \end{aligned} \tag{1}$$

This statistical model is composed of one dependent variable ($\ln\_b_{\text{size}}$), four explanatory variables (Shares, $\ln_{\text{Public\_owners}}$, CEO_{Dual} and In_{house}) and four control variables that are $\ln_{\text{Comp}_{\text{Size}}+1}$ and the local distribution variables north, south[3] and centre. Table 2 presents a short description of all variables above mentioned.

Empirical findings

Descriptive statistics

Descriptive statistics are show as follows. The median value of the number of directors sitting on the boards is equal to 3. Besides, it varies largely since it ranges from the case of a sole directorship to a maximum of 12 directors. Then, on average, the public owners hold the whole shareholding of SOEs (90.40%). Moreover, on average, the number of public owners is almost equal to 40. It varies largely since it ranges from the case of one public owner to the case of 276 public owners. Additionally, most SOEs are characterized by non-dual CEOs (CEO duality occurs only for the 7% of SOEs) and they are not in-house companies (only the 21% of SOEs are in-house companies). Then, the median value of number of salaried employees is equal to 45. It varies largely since it ranges from the case of 0 salaried employees to the case of 1316 salaried employees. With reference to the geographical distribution, the majority of SOEs are located in Northern Italy (63%), followed by Southern Italy and Sardinia

[2] OLS regression is the most used form of correlation analysis in social sciences (De Maris 2002). This method has been considered the fittest to the purpose of this study due to the fact that the study investigates the impact of more than one independent variables on a dependent variable ($\ln\_b_{\text{size}}$) other things being equal (De Maris 2002).

[3] Sardinia and Sicily have been included in the variable "south" since other prior studies (Guerrini and Romano 2014) have done the same.

Table 1 Characteristics of statistical population object of investigation. Source: Self-own elaboration

Steps	Characteristics
1°	Only entities included in the section *"Open data Partecipazioni PA"* available on the official website of the Italian Department of Treasury related to the year 2018[ab] have been considered
2°	Only entities with a legal form of a "società" and that are active companies[c] have been considered
3°	Only active companies located in Italy and operating in the water industry have been considered
4°	Only active companies located in Italy and operating in the water industry in which one or more public owner/s hold shareholding at least equal to 51% with all available data have been considered

[a]https://www.dt.mef.gov.it/it/attivita_istituzionali/partecipazioni_pubbliche/censimento_partecipazioni_pubbliche/open_data_partecipazioni/index.html

[b]In the official institutional web site of the Italian Department of Treasury, data for the year 2018 were the most recent at the time in which this analysis has been conducted

[c]A company is considered active whether it is registered with the Registrar of Companies and carrying on business. To be considered active, a business must not be inactive, ceased, suspended, liquidated, bankrupt, or have insolvency proceedings open (https://www.infocamere.it/documents/10739/57851/Glossario+Movimprese/ea9c2eb3-4156-438d-ab776f584d09a384?version=1.1)

Table 2 Variables used in the OLS statistical model

Variable	Description
$\ln\_b_{size}$	The natural logarithm of the number of directors sitting on the boards (Hasan and Butt 2009; Azeez 2015)
Shares	The percentage of direct shareholding hold by public owner/s (Chen and Al-Najaar 2012; Bresciani et a. 2017)
$\ln_{Public\_owners}$	The natural logarithm of the number of public owners (Li et al. 2016; Sidki et al. 2022)
CEO_{Dual}	A dummy variable taken value 1 if the CEO exists and the individual that assume this role is also the Chairman of the SOE and 0 otherwise (Qiao et al. 2017; Jia 2020)
In_{house}	A dummy variable taken value 1 whether the SOE is an in-house company and 0 otherwise
$\ln_{Comp_{Size}+1}$	The natural logarithm of the number of salaried employees plus 1 (Leoncini et al. 2016)
North	A dummy variable taken value 1 for each SOE sited in Northern Italy and 0 otherwise (Monteduro et al. 2011; D'Inverno et al. 2021)
South	A dummy variable taken value 1 for each SOE sited in Southern Italy or in Sardinia and 0 otherwise (Monteduro et al. 2011; Guerrini 2014; D'Inverno et al. 2021)
Centre	A dummy variable taken value 1 for each SOE sited in Central Italy and 0 otherwise (Monteduro et al. 2011; D'Inverno et al. 2021)

Table 3 Main descriptive statistics of the variables. Source: Gretl results

Variables	Mean	Median	S.D.	Minimum	Maximum
b_{size}	3.32	3.00	2.14	1.00	12.00
Shares	90.40	97.91	14.49	51.00	100.00
Public_owners	39.65	22.50	52.66	1.00	276.00
CEO_{Dual}	0.07	0.00	0.25	0.00	1.00
In_{house}	0.21	0.00	0.41	0.00	1.00
$Comp_{Size}$	137.10	45.00	232.30	0.00	1316.00
North	0.63	1.00	0.49	0.00	1.00
South	0.19	0.00	0.39	0.00	1.00
Centre	0.18	0.00	0.39	0.00	1.00

(19%). Only the 18% of SOEs are located in Central Italy.

Table 3 summarizes all the above.

The correlation issues[4]

The correlation matrix shows the relationship[5] between two variables (Pallant 2011). This study presents the correlation matrix in Table 4 indicating the correlation between $\ln\_b_{size}$ with other study variables. Precisely, it shows a positive correlation between $\ln\_b_{size}$ and $\ln_{Public\_owners}$ and between $\ln\_b_{size}$ and $\ln_{Comp_{Size}+1}$. Moreover, it shows a negative correlation between $\ln\_b_{size}$ and Shares. Additionally, independent variables do not seem to be correlated among others. This study also considers variance inflation factors (VIF) to analyse the issue of multicollinearity (Hamilton 2012). If VIF values are greater than 10, multicollinearity problems occur (Gujarati and Porter 2009). Conversely, there is no multicollinearity if the VIF value of each variable presents a value less than 10. How Table 5 shows, for each variable of this study, the VIF values are below 2. Hence, no multicollinearity problems occur.

Test for heteroskedasticity

Table 6 shows the Breusch–Pagan test for heteroskedasticity. Specifically, it reveals that the data does not have elements of heteroskedasticity.

Regression analysis

The main results of the OLS model suggest as follows. From a first overview and looking at the R^2 adjusted, it emerges that the model is able to explain a little more of the 35% of the analysed phenomenon. Furthermore, it allows to reject the null hypothesis that all the regression coefficients are equal to 0 at the 0.01 level since the p value associated with the F-statistic is very small. Then, looking at the relationship of each single independent variable with $\ln\_b_{size}$, it is possible to provide the following ulterior considerations. Firstly, it emerges that the variable $\ln_{public\_owners}$ is positively and significantly associated with $\ln\_b_{size}$. Conversely, the variable Shares is negatively and significantly associated with $\ln\_b_{size}$. Moreover, referring to control variables, it emerges that $\ln_{Comp_{Size}+1}$ is positively and significantly associated with $\ln\_b_{size}$[6].

Table 7 shows all the above.

Discussion and conclusion

In Italian SOEs, the main issues are linked to the presence of agency problems (Jensen and Meckling 1976) and the presence of political connections within boards (Menozzi et al. 2011; Giosi and Caiffa 2021). One of the much-debated issues either in the academic (Jensen 1993; Hermalin and Weisbach 2003; Chen et al. 2008; Liang et al. 2013) or in the Italian normative (Law 178 of 2010 and Law 175 of 2016) concerns the choice of board size in SOEs. This study has investigated what are the determinants of board size on a sample of 105 Italian SOEs operating in water industry for the main following reasons. The firms operating in water sector represent a classical example of companies mainly owned by one or more public administration/s (Mellah and Ben 2016; Utilitalia 2019). Therefore, the considerations presented in Sect. "The main characteristics of corporate governance in Italian SOEs" of this article surely are relevant for these companies. Additionally, there are also other prior literature (Romano and Guerrini 2014; Poomdeeying 2019) that explicitly cited enterprises operating in water sector when studying the typical characteristics of board of directors in Italian SOEs. Moreover, despite this sector is one of the most regulated by Italian policy-maker, literature has provided few contributions on corporate governance in Italian water SOEs (Menozzi et al 2011; Romano et al. 2013; Romano and Guerrini 2014). Romano et al. (2015) find that a larger board negatively influences water utilities' efficiency, without considering the

[4] To avoid collinearity problems, in this study, a control variable indicating whether SOEs are located in Northern Italy has not been taken into account in the OLS statistical model.

[5] This relationship can be categorized into three parts which are high (ranging from 0.50 to 0.99), low (ranging from 0.10 and 0.29) and medium (ranging from 0.30 and 0.49) correlation (Pallant 2011).

[6] This point is not surprising since this is a variable highly considered by all prior studies investigating the determinants of board size in all field of research, and the sign of this relationship is always strongly positive and statistically significant (Boone et al. 2007; Guest 2008).

Table 4 Correlation matrix. Source: Gretl results

	$\ln\_b_{size}$	Shares	$\ln_{public\_owners}$	CEO_{Dual}	In_{house}	$\ln_{Comp_{Size}+1}$	Centre	South
$\ln\_b_{size}$	1							
Shares	− 0.2	1						
$\ln_{public\_owners}$	+ 0.4	+ 0.0	1					
CEO_{Dual}	+ 0.1	+ 0.0	+ 0.1	1				
In_{house}	+ 0.0	+ 0.2	− 0.1	− 0.0	1			
$\ln_{Comp_{Size}+1}$	+ 0.5	+ 0.0	+ 0.4	+ 0.2	+ 0.2	1		
Centre	+ 0.1	− 0.1	− 0.0	− 0.1	− 0.1	+ 0.0	1	
South	− 0.0	− 0.2	− 0.1	− 0.0	+ 0.0	+ 0.2	− 0.2	1

Table 5 Test of multicollinearity—VIF. Source: Gretl results

Variable	VIF
Shares	1.087
$\ln_{Public\_owners}$	1.305
CEO_{Dual}	1.041
In_{house}	1.159
$\ln_{Comp_{Size}+1}$	1.448
Centre	1.127
South	1.235

Table 6 Heteroscedasticity test. Source: Gretl results

Heteroskedasticity test	$\chi2$ (7)	Prob > $\chi2$
$\ln\_b_{size}$	4.270970	0.748091

Table 7 Results of the OLS model. Source: Gretl results

Independent variables	OLS model		
	$\ln\_b_{size}$		
	Coefficient	*p* Value	
Intercept	1.20671	2.20E-03	***
Shares	− 0.01138	5.40E-03	***
$\ln_{public\_owners}$	0.08548	4.12E-02	**
CEO_{dual}	0.29240	2.01E-01	
In_{house}	0.00979	9.47E-01	
$\ln_{Comp_{Size}+1}$	0.16689	1.90E-06	***
Centre	0.03187	8.36E-01	
South	− 0.25894	1.03E-01	
R^2-adjusted		0.350939	
F-statistic		9.033069	
p Value		1.53E-08	

***Significant at 99%, **Significant at 95%, *Significant at 90%

factors affecting the board size. This is the first paper that analyses the determinants of board size on a sample of 105 Italian water SOEs. In line with US and UK studies (Guest 2008; Linck et al. 2008; Andrews 2022), this article concludes that Italian water SOEs' boards are not randomly structured. This study found support for the hypotheses that: a) the greater are the number of public owners, the larger will be the board size in Italian water SOEs; b) the greater are the degree of public ownership, the smaller will be the board size in Italian water SOEs. In line with other prior studies investigating some corporate governance characteristics in Italian SOEs (Calabrò et al. 2013; Allini et al. 2016), these two main results find its support from the agency theory (Jensen and Mecklig 1976). Indeed, this theoretical lens suggests that board size may be influenced by the ownership structure (Andrews 2022). Precisely, following the agency theory, the more public owners there are, the more are conflicting the interests that they wish to pursue (Gunasekhar and Dinesh 2017). Consequently, the owners influence the decision-making processes through the pressure that they exercise on board members (Anderson et al. 2003). Besides, directors believe that the interest of the collective converges to protect the owners' interests in Italian water SOEs (Grossi and Thomasson 2015). Some authors who drew from agency theory (Jensen and Meckling 1976) have also substantiated that if

degree of public ownership is high in SOEs, public owner/s has/have a greater incentive to monitor managers (Shleifer and Vishny 1986; Mishra 2011; Munisi et al. 2014), therefore rendering a greater board size redundant. In the case of an higher degree of public ownership concentration the need for an advisory role decreases (Guest 2008; Chen and Al-Najjar 2012; Munisi et al. 2014) since public owners are able to hold more under control the administration of the State-owned enterprises. Also, in the case of a higher public ownership concentration, the transactions costs too are lower compared to the cases where more number of owners (private and public) are present (Hoppe and Schmitz 2010). For all these reasons, this study confirms that if the degree of public ownership concentration is high, a greater board could be redundant (Boone et al. 2007). These results not only find their fundamentals in the "principal-agent" relationship provided by the agency theory, but they also add a new contribution to this theoretical lens. Indeed, they suggest that in the case of an essential service for the survival of humanity such as the water resource, the relationship "principals-agents" destroys value, since it does not consider the wellness of citizens (the ultimate owners). This study emphasized the failure of "principals-agents" relationship and specifically the failure of public property in Italian water SOEs. Citizens pay the taxes that are supposed to finance public services and are therefore the only ones fully interested in ensuring that there are no influences that hinder the smooth running of the board and that public services are run efficiently. Di Robilant (2014, pg. 326) pointed: *"Water involves questions of stewardship and protection of the interests of future generations. Water also implicates fundamental non-human, ecological interests. These interests are not likely to be represented when water is governed through private property or public property. The concept of 'common goods' is being revived to provide an alternative to public and private ownership. Ownership of 'common goods' differs from public ownership in an important way because it gives citizens collectively not only use entitlements, but also the right to participate in management decisions"*. In this regard, I encourage a deliberative democratic property forms (Di Robilant 2014), as a pragmatic and functional reality, and the inclusion of citizens in the board of directors (Andrews 2022) in Italian water SOEs. In particular, I propose to regulators to draft laws that establish a direct involvement of the citizens (the ultimate owners) in the decision-making processes of Italian water service. Primarily, ensuring their presence in the boardroom of Italian water SOEs, then, with the transition from the public ownership (the government that operate as *"agent"* of citizens) towards a deliberative democratic property as a pragmatic and functional reality (Di Robilant 2014), characterized by the inclusion of citizens (as ultimate owners). Though, it could happen that citizens will have no interest in involving themselves in decision-making processes of Italian water SOEs. Indeed, for each of them, the opportunity cost could be high, while the benefit is divided among all other citizens. To overcome this point, I suggest the following. Firstly, giving some incentives to citizens who decide to involve themselves in all this (e.g. the possibility to benefit from the water resource without pay the bill). Secondly, the involvement of citizens in the decision-making processes of Italian water industry for a small period, opting for a voluntary rotation system, may be encouraged. Future research could investigate if these solutions enhance efficiency in Italian water SOEs.

This study has some limitations. Only the Italian SOEs operating in water industry has been considered. Consequently, the obtained result might not occur or be less pronounced in SOEs operating in other industries or/and in other countries. Additionally, this study considers only the year 2018. Hence, there is a loss of information related to the observation of the phenomenon for only one year. Although this study considered a large set of variables, there may be other determinants of board size in Italian water SOEs which have not been considered. Future studies could conduct other investigations to overcome these limitations.

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Declarations

Conflict of interest I have no conflict of interests to declare.

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