Theoretical Economics Letters, 2022, 12, 1227-1258
https://www.scirp.org/journal/tel
ISSN Online: 2162-2086
ISSN Print: 2162-2078

Economic Crisis and Corporate Governance: How Can Board Independence and Expertise Maximize the Firm Value?

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How to cite this paper: Crifo, P., & Roudau, G. (2022). Economic Crisis and Corporate Governance: How Can Board Independence and Expertise Maximize the Firm Value? *Theoretical Economics Letters, 12,* 1227-1258.
https://doi.org/10.4236/tel.2022.125066

Received: July 9, 2022
Accepted: September 12, 2022
Published: September 15, 2022

Abstract

In the context of recurrent crises and the necessity to move to more sustainable firm level changes, this paper analyzes the trade-off between board's dual role of monitoring and advising the CEO, especially relevant for the integration of sustainable development into corporate strategy, depending on board independence and expertise. We propose a theoretical model in which boards may choose to be either monitoring or advisory type towards the CEO. In this framework, the board's incentives to adopt a high monitoring level are non-monotonically (U-shaped) related to the expertise level. On the other hand, the incentives for an advisory board to discipline the CEO are increasing with expertise, if the business has high opportunity for growth. Finally, under specific parameter values, the model generates a disciplining effect of expertise in the sense that the more expert the board is, the less opportunistic the CEO is. We then test these theoretical results using a dataset on the French 120 largest listed companies over the 2006-2011 period. Empirical evidence reveals that expertise plays a mediating role in the relationship between independence and performance in French firms. Directors' competences for sustainable development hence are likely to play a crucial role for firms to integrate such issues into their core strategy.

Keywords

Corporate Governance, Board, Independent Directors, Expert Directors, Sustainability

1. Introduction

Over the last two decades, the growing recognition that our development model is running out of steam, and our increased awareness of the environmental and social damage that economic activity can produce, leading to recurrent global economic crises, mean that corporate sustainability is increasingly called upon (Crifo & Rebérioux, 2016). Customers, communities, certain investors, and the general public are demanding accountability from companies and their main governance bodies to integrate sustainable development issues (Crifo & Forget, 2015). How can the board of directors respond to this demand? Are there some desired characteristics of the board of directors? Parallel to this phenomenon, the boards of directors of most OECD companies have come increasingly to contain a majority of independent directors. In the US, for instance, the percentage of independent directors for large public listed firms has shifted from 20% in the 1950s to approximately 75% by the mid-2000s (Gordon, 2007). In continental Europe or in the UK, the percentage of independent directors has increased as well over the last 15 years, to reach for example more than 50% in French large listed companies (Bourjade et al., 2016). Why do shareholders focus on independence? This issue is all the more important as no clear empirical consensus exists on whether independence significantly improves firm performance (Adams et al., 2010; Wintoki et al., 2012). In this paper, we develop a model and estimate its main predictions on French data to study the mediating role of expertise and its impact on the independence-performance nexus, in the context of global economic crises that revealed severe shortcomings in corporate governance and lead towards increasing concerns for sustainable development in firm governance bodies.

Boards of directors have two major roles: monitoring and advising the management. The quality of both functions is decisive for corporate performance. The monitoring role implies management oversight, ensuring financial transparency and serving as a "watchdog" for shareholders, whereas the advisory role involves giving counsel to the CEO, setting strategy, and approving major expenditures, mergers and acquisitions (Demb & Neubauer, 1992; Hermalin & Weisbach, 2003; Adams, 2009; Kim et al., 2014). It is conventional wisdom today that board members allocate their time across the monitoring and advisory tasks according to their respective background, expertise and independence (Faleye et al., 2013; Schwartz-Ziv & Weisbach, 2013). In principle, board members internalize the shareholders' objective, share their time between tasks and make their decisions in order to protect the shareholders' interests. This has consequences for regulation about the independence, the competencies and the incentives of non-executive directors and is often promoted by codes of governance (see the literature review and comparative analysis of Zattoni and Cuomo (2010)). From an agency perspective (see e.g., Jensen and Meckling (1976)), independence should be beneficial by reducing the likelihood of collusion with corporate executives. However, independent directors have an information disadvantage compared to CEO that may jeopardize directors' efficiency (Adams & Ferreira, 2007). In the stewardship theory in turn, shareholder interests are maximised by shared incumbency of board chair and CEO (Donaldson & Davis, 1991). In the extreme, this informational deficit may make the board act either as a monitoring or as an advisory type (Baldenius et al., 2014). Yet, in the team production theory (Kaufman & Englander, 2005; Blair & Stout, 1999), boards should thus include directors with firm-specific expertise (managers employees), in order to bring the firm's know-how to the table. The resource dependence and the stakeholder theories further advocate that boards of directors should serve as a bridge between companies and their stakeholders, not only legitimizing but also creating connections and helping the firm to respond and conform to societal expectations (Lückerath-Rovers, 2009; Pfeffer & Salancik, 2003; Freeman, 1984; Donaldson & Preston, 1995). This paper shows that taking into account expertise helps explain the ambiguous benefits and costs of board independence and its non linear relationship with performance.

This paper addresses the following research question: *how does the independence and expertise levels board directors affect the optimal board behavior* (*monitoring/advisory*) *that maximizes the firm value?* The issue of Board independence and expertise and the monitoring-advising trade-off is important from several perspectives. From a regulatory perspective, our approach invites to consider not only independence, as in most existing codes of corporate governance, but also some expertise requirements, in order to better fulfill the complex missions attributed to boards. From the shareholders' perspective, our analysis suggests that in the nomination of board members, the relative bargaining power of CEOs and shareholders can be reflected in the independence and expertise of the nominated directors. From a director's perspective, our examination of the interplay of independence and expertise highlights the interest of viewing board functioning and decisions within a team production context where both internal and external competences may be valuable. It also helps understanding the mediating effect of the board of directors between CEOs and the firm's sustainability performance thus its ability to account for various stakeholders demands. Finally, from a purely research perspective, understanding various behaviors of the board enable to explain the non linear pattern observed in empirical data on the relationship between board members' characteristics and firm performance.

To address these issues our research methodology relies on a two-step approach. In a first step we propose a theoretical model capturing several important behaviors and mechanisms identified in the existing literature. This model allows understanding the determinants of board behavior (monitoring versus advising the CEO) depending on the level of independence and expertise of its members. In a second step, we test the main predictions of the model using French data on the 120 biggest listed companies over the 2006-2011 period.

The rest of the paper is organized as follows. Section 2 presents the literature review on which our theoretical and empirical analysis is based. Section 3 develops the theoretical model proposed and analyzes its main equilibrium properties. Section 4 presents the empirical estimation on French data. Section 5 concludes, and suggests several directions for further research.

2. Literature Review and Conceptual Framework Development

Our approach contributes to the established literature by identifying two main board attributes—independence and expertise—that determine the monitoring and advisory propensity and the related trade-off among both (see Adams et al., 2010; Wang et al., 2015; Schmidt, 2015; Faleye et al., 2018; Croci et al., 2020). On the one hand, independence is expected to minimize the probability of collusion between directors and corporate officers (Li et al., 2022). An independent director should in fact be independent of the management, the blockholders (controlling shareholders), the firm's affiliate and the providers of professional services (legal, consulting or financial) to the company (Gong et al., 2021; Adams, 2012; Crespi-Cladera & Pascual-Fuster, 2014; Atty et al., 2018). Our approach thus contributes to the literature showing that more independent boards are likely to increase managerial accountability and monitoring (Jensen & Meckling, 1976; Tirole, 2001). On the other hand, expertise is an alternative proxy to measure boards' ability to provide their services (Cunningham, 2008; Wagner, 2011). Expertise is inherently multi-dimensional and ranges from knowledge of the industry (Dass et al., 2014) to firm specific information and other director-craft competences such as political connections, financial literacy or sustainable development goals (Ali et al., 2022; Ammari, 2022; Gilani et al., 2021; Naheed et al., 2021; Crifo et al., 2018; Sekarlangit & Wardhani, 2021; Burak Guner et al., 2008; Mire, 2016). Directors develop their expertise through their education, their professional experience and their business activity with the firm (Anderson et al., 2011; Reeb & Zhao, 2013). Our model contributes to this literature by highlighting that whereas expertise may improve advisory quality (Dass et al., 2014), it comes at a cost: a lack of independence, and a greater leniency towards CEOs (Tirole, 2001).

Hence, the board's propensity of being monitoring or advisory type is intimately related to board members' characteristics in terms of independence and expertise. A considerable literature in turn examines the opposition, within board, between insiders and outsiders as reflecting an opposition between advisers assimilated to insiders and monitors assimilated to outsiders (Haque et al., 2022; Adams & Ferreira, 2007; Harris & Raviv, 2008; Faleye et al., 2011; Linck et al., 2008). A monitoring-type board is generally considered less lenient towards the CEO than an advisory-type board (Weisbach, 1988; Denis et al., 1997; Goyal & Park, 2002). But loyalty from a competent board is also considered very efficient from the shareholder's perspective (Wagner, 2011). Following these recent developments on the trade-off between independence and expertise, we consider here that the monitoring versus advisory dichotomy is an endogenous decision made by board members. Consequently, we propose a theoretical model which accounts for such a decision and analyzes its impact on corporate strategy and performance. In turn, we consider that the decision to adopt an advisory-type (lenient towards the CEO) or monitoring-type (hostile towards the CEO) depends on board composition, notably on the proportion of independent and expert directors. Our main results contribute to this research strand by showing that this may explain the ambiguous (non linear) relationship between board independence and firm performance.

Following this existing literature, we study the interplay between board composition (independence and expertise), board type (monitoring and advisory) and CEO decisions in two steps.

In the first step, we rely on a theoretical approach and develop a two-stage model (governance and production) of a firm whose CEO has private information about the probability of success of an investment and board members are either monitoring or advisory types as in previous frameworks (see e.g. Baldenius et al., 2014). Moreover, board composition is characterized by the degree of expertise and independence of its members. The hypotheses of the model build upon the existing literature as follows.

During the governance stage, the board, which protects the interests of shareholders, chooses to be either monitoring or advisory type. A monitoring board tries to uncover the CEO's information while an advisory board tries to provide valuable information and supports to the CEO. Departing from the usual outsiders/monitors versus insiders/advisers dichotomy, we consider, as in Baldenius et al. (2014), that both types of board engage in monitoring and advisory activities but time allocation across the two tasks depends on board members' independence and expertise (Katolnik et al., 2022; Faleye et al., 2011). Independent board members have a comparative advantage in monitoring and experts are better at the advisory function. Hence, depending on the level of expertise and independence of its members, the board chooses its type (monitoring/advisory) in the best interest of the shareholders. During the production stage, the CEO chooses between two projects: shareholders' preferred project leading to continue the initial project approved by the board, or its own project with private benefit leading to restart a new project providing more managerial private benefits and therefore being less congruent with the shareholders' objectives. In both cases, the CEO is constrained by board monitoring.

The model in turn enables to answer our research question on the optimal board behavior (monitoring/advisory) that maximizes the shareholder value depending on the independence and expertise levels of director in two directions. First, for a given level of expertise, boards with a high level of independence (above a certain threshold) choose to be monitoring, and boards with a low level of independence choose to be an advisory type. This result always holds at low levels of expertise, in the sense that under a given expertise threshold, boards always choose to be monitoring. Above this expertise threshold however, the optimal share of monitoring-type boards is U-shaped (first decreases and then increases) with the expertise level. In other words, increasing the presence of experts inside the boardroom first reduces and then increases the incentive for being a monitoring-type board. Moreover, as independent directors suffer from an informational deficit, when the relative cost of such a deficit increases, the incentive to be a monitoring-type board decreases. Second, our model shows that below the expertise threshold, low independence implies less managerial discipline, and above this threshold, board monitoring always succeed in reducing CEO opportunism. Second, the model also helps identifying a disciplining effect of expertise. In fact, an increase in directors' expertise may mitigate managerial opportunism if its benefits dominate agency costs associated with low alignment of interests between CEO and shareholders. Overall, our approach suggests that expertise mediates the relationship between board independence and performance and may explain the ambiguous results found in the literature (Bhagat & Black, 1999; Adams et al., 2010; Wintoki et al., 2012). At low levels of expertise, there is an unequivocal (positive) relationship between independence and performance, but above a certain threshold, the relationship becomes non-linear. Regarding the sustainable development agenda, these results confirm the need to train inside directors to respond to corporate sustainability, as suggested in Crifo et al. (2018), as expertise, in particular on sustainability issues, plays an important role in the advisory/monitoring tasks of the board thereby on the performance of the company (Herren Lee, 2022).

In the second step, we propose to test on French data the relationship between the percentage of expert and independent directors and firm operating performance, on the 120 largest listed companies (SBF120 index) over the 2006-2011 period. This empirical analysis hence helps answering our research question on the interplay between board composition (independence and expertise), board type (monitoring and advisory) and CEO decisions in the French context. We observe a weak concave positive relationship between the percentage of independent directors and operating performance when controlling for the level of expertise, suggesting a decreasing marginal benefit of board independence. We also show that there is a convex positive relationship between the percentage of experts and firm performances and a positive correlation between the percentage of independent expert directors and firm performance, highlighting the non-linear effect of expertise and its potential disciplining effect. Independence and expertise seem to be complementary for firm performance. The empirical evidence supports the overall predictions of the model.

Overall, our approach thus makes three novel contributions to this literature. First, following Wagner (2011), we examine board effectiveness along two dimensions, independence and expertise, which are crucial to understand the recent changes in corporate governance in most OECD countries. Indeed over the last several years, legislators and regulatory bodies have adopted governance codes promoting not only independence, but also financial and industry expertises to address poor corporate governance and the exploitation of minority shareholders (Defond et al., 2005; Burak Guner et al., 2008; Dass et al., 2014). Our approach contributes to this literature by proposing a theoretical examination of the consequences of such policies on firm decisions and performance. We show in particular that expertise may help alleviate the detrimental effect of low independence on firm performance, thereby disciplining managers to the benefits of shareholders. Moreover, the model gives some insights at the industry level. Firms compete for directors, especially regarding directors' expertise. There may be some trade-offs between the supply of independence and expertise inside the boardroom (Keys & Li, 2005; Masulis et al., 2012; Knyazeva et al., 2013). The model enables to compute the equilibrium at the industry level taking into account the choice of governance and production of the other firms. It shows different optimal strategy depending on the ability of the firm to hire independent or expert directors. To the best of our knowledge, it is the first model tackling this issue.

Second, following Baldenius et al. (2014) and Katolnik et al. (2022), we investigate the monitoring-advising trade-off to understand the board composition-performance nexus. Our model differs on two aspects. On the one hand, we assume that the directors' behavior is determined at the board level. In other words, we do not model information sharing and coordination costs within the board, but rather focus on the board as a holistic entity and determine the optimal board behavior (monitoring/advisory) that maximizes the shareholder value depending on the independence and expertise levels of its directors. On the other hand, we argue that both independence and expertise are important determinant of board behavior.

And third, we propose a theoretical framework that sheds a new light on the absence of consensus in the literature on the independence-performance relationship (Bhagat & Black, 1999; Wintoki et al., 2012). Our model and empirical evidence suggest that expertise should be taken into account (Ali et al., 2022; Gilani et al., 2021) as it may affect the trade-off between monitoring and advisory functions, supporting the recent results of Wang et al. (2015), Dass et al. (2014) and Faleye et al. (2013). Moreover, our model also documents a non linear relationship between expertise, independence and firm performance confirming the need identified in previous literature (Crifo et al., 2018) to train inside directors to improve corporate performance.

3. A Model of Optimal Board Behavior

In this section we describe the first step of our research method, namely the development of a theoretical model of optimal board behavior, with timeline as depicted in **Figure 1**.

3.1. Timing of the Model

The model has two periods delimited by three dates ($t = 0, 1, 2$). The economy is composed of a continuum of CEOs, directors and shareholders.

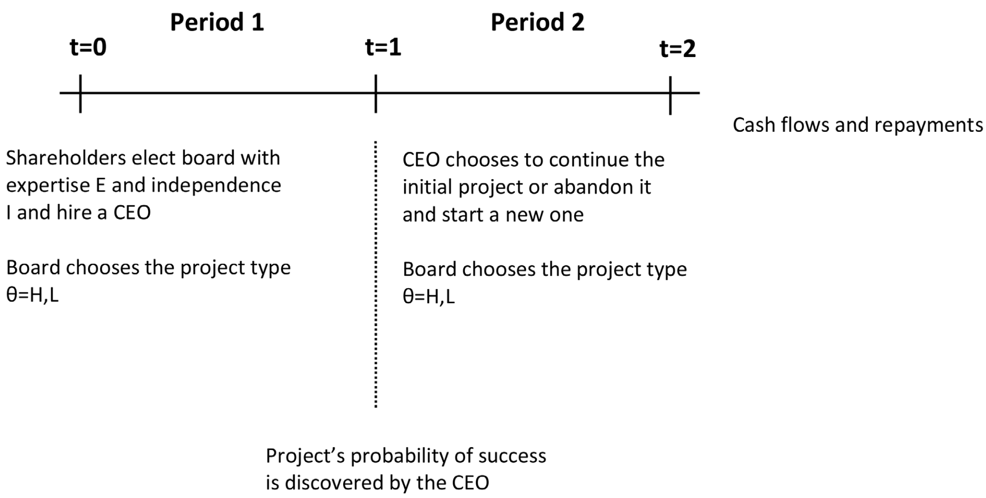

Figure 1. Timing of the model.

Period 1*. The CEO and the board interact on the new project* (*advices and monitoring*)

At date 0 (beginning of the first period), the shareholders hire a CEO and elect a board characterized by a degree of independence $I \in [0, 1]$ and a degree of expertise $E \in [0, 1]$. Expertise refers to the set of knowledge and competencies related to directors' duties, that is financial and extra-financial (sustainable development) information (see e.g. Dass et al., 2014; Sekarlangit & Wardhani, 2021). Independence captures the "distance" or connection between board members and the CEO, a higher independence meaning a lower propensity of collusion between the board and the CEO (see e.g. Upadhyay et al., 2021). The CEO and the board face a project decision with probability λ (with probability 1 − λ the project is not viable and the firm is not created).

In period 1, if the firm is created, the CEO proposes to the board two alternative projects: a routine project requiring high advising and low monitoring efforts (L-type project), and a complex project requiring high monitoring and low advising efforts (H-type project). The advisory task implies giving counsel to the CEO on strategy and expenditures and the monitoring task involves uncovering CEO's information and ensuring transparency, see Hermalin and Weisbach (1998); Adams and Ferreira (2007); Faleye (2015).

Period 2*. The CEO gathers information and the project is continued or abandoned* (*and a new project restarts*)*.*

At date 1 (beginning of period 2), the CEO observes the project's probability of success, materializing the information asymmetry between board members and CEO. Then, the CEO chooses to either continue the initial project, maximizing the shareholders' profit, or to abandon it and to start a new one. The restarted project is less attractive for the shareholders but generates a personal private benefit for the CEO. It is a one-period project on which the board does not provide any piece of advice or monitoring.

Production takes place in period 2. The economy is composed of two industries: a final good industry and an intermediate goods industry. Intermediate goods are used as factors of production in the final good industry. The final good is produced using two different types of intermediate goods: the goods produced by continued firms and the goods produced by restarted firms (for a related modelling structure in the context of entrepreneurship and ability-biased technical change, see Crifo and Sami (2008)).

At the end of period 2, cash flows and repayments are realized and the firm is liquidated.

The sequence of events may be summarized as follows:

- $t = 0$, period 1: shareholders elect a board and hire a CEO. The CEO proposes a project (routine or complex) and the board chooses to implement either the routine (type L) or the complex (type H) project.
- $t = 1$, period 2: the project's probability of success is discovered by the CEO. The CEO decides to continue the initial project or to abandon it and to launch a new one. Production takes place.
- $t = 2$: Cash flows are realized, the firm is liquidated.

3.2. Technology and Preferences

At date 0, the shareholders invest \$1 in the firm, and they elect a board and hire a CEO. The CEO uses the capital to produce goods and generate cash flows during the production stage (period 2). The shareholders, the board and the CEO share the generated cash flows. The CEO also extracts some private benefits if the project is abandoned and a new project is launched in period 2.

Let β_c, β_s, and β_b denote the relative share of profits received by the CEO, the shareholders and the board in period 2. Since the firm is liquidated at the end of period 2, we have: $\beta_c + \beta_s + \beta_b = 1$.

The *preferences of the CEO*, *the shareholders*, *and the board*, respectively U_c, U_s, and U_b, are defined by the following utility functions:

$$U_c = \beta_c \Pi + \underline{\lambda} \psi \chi,\ U_s = \beta_s \Pi,\ U_b = \beta_b \Pi \tag{1}$$

where χ is an indicator function such that $\chi = 1$ if the period 1 project is abandoned and a new project is launched and $\chi = 0$ otherwise and Π is such that

$$\Pi = \overline{\pi}^{\theta} \quad \text{if the period 1 project is continued}$$

and $\Pi = \underline{\pi}$ if the period 1 project is abandoned and a new project restarts

Where $\overline{\pi}^{\theta}$ is the expected payoff of a project of type $\theta = H, L$ continued in period 2, $\underline{\pi}$ is the expected payoff, $\underline{\lambda}$ is the probability of success and ψ is the private benefit extracted by the CEO from a new project launched in period 2. The expected payoffs of a project either continued from period 1 to period 2, $\overline{\pi}^{\theta}$, or launched in period 2, $\underline{\pi}$, are defined by:

$$\overline{\pi}^{\theta} = \overline{\lambda} B^{\theta} \overline{V},\ \underline{\pi} = \underline{\lambda} \underline{V} \tag{2}$$

where $\overline{V}$ and $\underline{V}$ are the present value of the continued and the restarted project, and B^{θ} is the return to board efforts for project $\theta = H,L.$

The *return to board efforts* is the product of two components, who are two complementary inputs of board efforts: the return to advisory effort a^{θ} and the return to monitoring effort m^{θ}, that is: $B^{\theta} = a^{\theta} \times m^{\theta}$, $\theta = H, L$.

A routine project implies a low monitoring/high advisory effort, and is denoted by $\theta = L$. The degree of board expertise increases the quality of advising but decreases the quality of monitoring, while the degree of independence has no impact (or a fixed exogenous one). Normalizing boards' time to 1, a fraction δE of this time is dedicated to advising, the remaining fraction $1 - \delta E$ is dedicated to monitoring the CEO. In other words, in routine projects the marginal return of the advisory effort, denoted by a^L, increases with the degree of expertise, and the marginal return of the monitoring effort, denoted by m^L, decreases with the degree of expertise:

$$a^L = \delta E, \quad m^L = 1 - \delta E \quad \text{where} \quad 0 < \delta E < 1.$$

A complex project implies a high monitoring/low advisory effort, and is denoted by $\theta = H$. The degree of board independence increases the quality of monitoring but has a no impact on the quality of advising, while the degree of expertise has no impact (or a fixed exogenous one). In other words, complex projects require a strong monitoring effort for which independent members are more effective. Denoting by I the degree of board independence, the marginal return of the advisory effort, denoted by a^H, is fixed, and the marginal return of the monitoring effort, denoted by m^H, increases with the degree of independence:

$$a^H = \varphi, \quad m^H = g(I) \quad \text{where} \quad 0 < g(I) < 1, \quad g'_I > 0, \quad g''^2_I \leq 0.$$

We assume that advisers are less effective at the monitoring task as in Adams and Ferreira (2007): $m^L < m^H \Leftrightarrow 0 < 1 - \delta E < g(I)$ and $a^H < a^L \Leftrightarrow 0 < \varphi < \delta E$,. Moreover to ensure that shareholders have incentives to invest in the firm, we also assume that the net present value is positive:

$$\bar{\lambda}\left(g(I) + 1 - \delta E\right)\bar{V} > 1/1 - \beta_c - \beta_b$$

Regarding the *production technology*, in period 2 the final good in the economy is produced using two different types of intermediate goods: the goods produced by continued firms ($\bar{x}$) and the goods produced by restarted firms ($\underline{x}$), according to the following technology: $y = \bar{x}^{\alpha} \underline{x}^{1-\alpha}$, $0 < \alpha < 1$.

After some computations (see details in appendix (6.1)), the payoffs from each type of firms are given by:

$$\bar{\pi}^H = \bar{\lambda} B^H \frac{1-\alpha}{\alpha} \bar{x}, \ \bar{\pi}^L = \bar{\lambda} B^L \frac{1-\alpha}{\alpha} \bar{x}, \ \underline{\pi} = \underline{\lambda} \frac{\alpha}{1-\alpha} \underline{x} \tag{3}$$

where $B^{\theta} = a^{\theta} m^{\theta}$, is the return to board efforts, $\theta = H, L$ as defined above.

3.3. Equilibrium

We present here the basic properties of the model, leaving the mathematical resolution in the appendix (see 6.2). This section interprets the different equilibria at the firm and the industry level depending on the board and the CEO decisions.

Proposition 1. The marginal benefit of expertise and the board monitoring type.

When $E \le \varphi/\delta$*, all boards choose the high monitoring project* (*H-type*).

When $E > \varphi/\delta$*: the share of firms with a monitoring board* (*H-type*) $(1-I^*)$

- *Increases with the level of board expertise* (E) *when H-type boards have a low advisory quality* $(1 < a^H < 1/2 \Leftrightarrow 1 < 1/\varphi \le 2)$.
- *Increases* (*resp. decreases*) *with the level of expertise* (E) *when* $E > E^{**} = 1/2\delta$ (*resp.* $E \le E^{**} = 1/2\delta$) *and H-type boards have a high advisory quality* $(1/2 < a^H \le 1 \Leftrightarrow 2 < 1/\varphi \le 4)$.

Proof. See appendix 6.3.

Figure 2 illustrates the board's monitoring choice (H or L) depending on the expertise and independence board degree.

Below the threshold $E^* = \varphi/\delta$, the high monitoring level is always optimal. In this case, the degree of expertise (E) and the corresponding advisory quality ($a^L = \delta E$) are too low for a routine (L) project to be an optimal strategy. All boards therefore choose the complex-high monitoring (H) project.

When $E > E^* = \varphi/\delta$, both types of projects are optimal and may thus co-exist in the industry. The basic trade-off depends on the level of expertise as follows. When the expertise level increases, a routine project (low monitoring) has a decreasing monitoring quality ($m^L = 1-\delta E$) and an increasing advisory quality ($a^L = \delta E$); while a complex project (high monitoring) has a constant advisory quality ($a^H = \varphi$) and increasing monitoring quality. The share of firms with a complex-high monitoring (H-type) project in the industry is given by $1-E^* = 1-g^{-1}\left(1/\varphi\delta E\left(1-\delta E\right)\right)$.

If the advisory quality of a high-monitoring board ($a^H = \varphi$) is high, the share of firms with a monitoring (resp. advisory) board increases (resp. decreases)

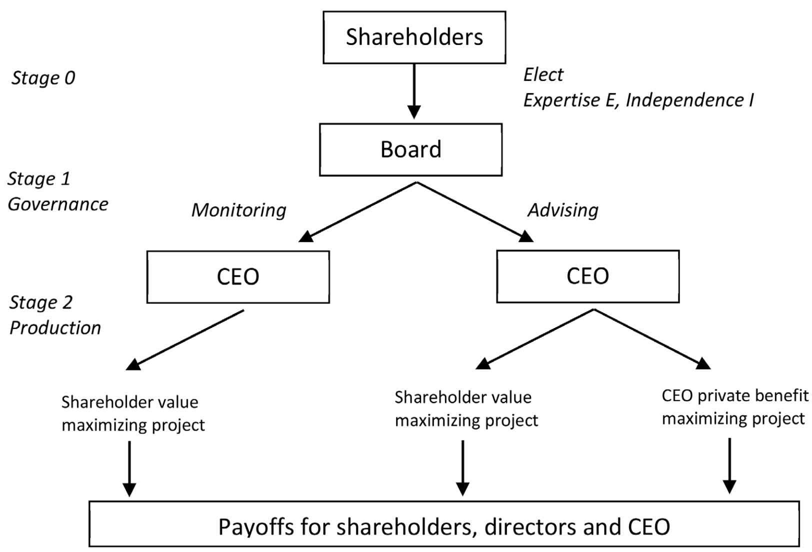

Figure 2. Overview of board and CEO decisions.

with the level of expertise E. As more and more experts are present inside the boardroom, the opportunity cost and the resulting quality of monitoring decreases more rapidly compared to the improved advisory quality, and boards have stronger incentives to choose the complex-high monitoring project. This result is corroborated by Burak Guner et al. (2008) and Armstrong et al. (2014) who show a positive correlation between the share of financial independent directors and firm performance or transparency, suggesting a high monitoring type board.

On the contrary, if the advisory quality of a H-type board is low (low φ), the relationship between the share of firms with a high level monitoring (H-type) board and expertise is non-monotonous. At low levels of expertise below the threshold $E^* = 1/2\delta$, an increase in the level of expertise raises more rapidly the advisory quality compared to the reduced monitoring quality, and boards have stronger incentives to choose the routine-low monitoring type. And vice versa above the threshold, boards have stronger incentives to choose the complex-high monitoring type project when expertise increases. The maximum share of firms with routine-low monitoring type board is equal to $1/4\varphi$ at $E^* = 1/2\delta$. Hence, the lower the advisory quality of a monitoring board (the lower ϕ), the lower the share of firms with a complex project-high monitoring board at the industry level. This result is convergent with Wagner (2011) who shows that loyal competent board may be in the interest of shareholders under some conditions. However, the model shows a complementary effect between independence and expertise at high expertise levels.

In other words, when expertise is low but above the threshold E^*, the marginal benefit of adding experts is high and the incentives to adopt an advisory type (low monitoring level) are increasing. When expertise is high, the marginal benefit adding experts is low, and the incentives to adopt a monitoring board (high monitoring level) are increasing. Hence the relationship between the share of firms with an advisory board and expertise is non-monotonous (concave, see **Figure 3**).

Proposition 2. Expertise and the advisory cost of a monitoring board

The lower the advisory quality of monitoring boards (*the lower* φ), *the lower the minimal expertise level necessary for complex projects/high monitoring and routine projects/low monitoring to coexist at the industry level*, *and the lower the share of firms with a high monitoring board at any expertise level.*

Proof. The minimal expertise level for monitoring and advisory boards to coexist is φ/δ. This threshold is proportional to the advisory quality of complex projects (φ). The share of firms with a complex project-high monitoring board is given by $1-g^{-1}\left(1/\varphi\delta E\left(1-\delta E\right)\right)$. A decrease in φ increases the threshold level of independence that makes the board indifferent between a low and a high monitoring level because g is a strictly increasing concave function. When φ decreases, the threshold of independence required for the high monitoring type to be optimal increases, and the resulting share of firms with a monitoring board then decreases.

In other words, the lower the advisory quality of monitoring boards φ the higher the offsetting level of independence required to raise the quality of monitoring, and therefore the lower the incentives to adopt the high monitoring level. Hence, a low advisory quality for a high monitoring board may jeopardize the benefits of independence and reduce the opportunity cost of low monitoring board. This result is convergent with Adams and Ferreira (2007) who show that in case of high information deficit, the board has the incentive to be advisory (friendly) type.

Proposition 3. Incentives to restart the project and CEO compensation

The share of firms with an advisory board which restart the project decreases with the CEO's private benefit (ψ) *and increases with the CEO's profit share* (β_c).

Proof. See appendix 6.4

By assumption, the expected payoff of the restarted project cannot be higher than the expected payoff of the continued project. The increase in the CEO's private benefit decreases the minimal expected payoff of the restarted project necessary for the CEO to abandon the initial project, and increases the minimal expected value of the continued project required for firms to produce it. As the share of firms with a high level monitoring board is independent from the private benefit or the CEO profit share of the restarted project, the only adjustment process at play is the increase in the share of firms with an advisory board that choose to continue the initial project. Interestingly, proposition 3 shows that advisory boards may have a disciplining effect on CEO if the private benefit of the restarting project increases, and if the CEO's profit share decreases. In other words, an advisory board is less successful with small CEO's opportunistic behaviors and high CEO compensation levels.

Proposition 4. The disciplining effect of expertise

Below the threshold E^*, *the share of firms with a monitoring* (H-*type*) *board that continue the initial project is independent of the expertise level.*

Above the threshold E^*, *the share of firms with an advisory board* (L-*type*) *that continue the initial project increases with the level of expertise if the relative expected value* ($\bar{V}^L - \underline{V}$) *compared to the expected share of successful* L-*type firms is increasing with the expertise level.*

Proof. Below $E^* = \varphi/\delta$, the share of firms with a H-type board that choose to restart a new project is constant and independent on the expertise level according to Equation (25). Above E^*, the share of firms with an advisory board that choose to continue the initial project is given by Equation (20). The expected successful share of firms with an advisory (L-type) board $\lambda(1-\delta E)\mu(I^*, E)$ is decreasing with the level of expertise, hence the share of firms with a monitoring board is increasing with expertise. The incentive value ($\bar{V}^L - \underline{V}$) is decreasing with the expertise level because the value derived from successful monitoring boards is increasing. The disciplining effect of expertise exists only if the ratio between the incentive value and the expected share of successful advisory boards increases with the expertise level.

Regarding the CEO's decision (to continue or to abandon the initial project), when the board is monitoring, a low expertise level more likely leads to managerial opportunism (restart a new project providing private benefits). Above the expertise threshold, all firms with a monitoring board continue the initial project. Moreover, managerial opportunism in firms with an advisory board (those who decide to restart a new project) decreases with expertise if and only if the expected value of the initial project is worth it. Proposition 4 shows that for low expertise levels, increasing expertise does not affect the CEO's incentives to continue the project or abandon it and restart a new one. For high level of expertise, increasing expertise raises the incentives to continue the initial project if it is profitable enough.

The main results of propositions 1 to 4 can be summarized by Figure 3.

Regarding corporate performance, the model suggests that the relationship between independence and performance is non-monotonous and mediated by the level of expertise. At low levels of expertise, the relationship between independence and firm performance is weakly positive. At high levels of expertise, when both types of boards co-exist, the relationship between independence and performance is more complex. Conditional on expertise, the model predicts a positive relationship between independence and performance only above a given threshold of independence. Regarding expertise, there is a positive relationship between expertise and firm performance if the disciplining effect operates above the threshold a^*. Otherwise, a negative correlation may be highlighted. The board with high independence and expertise levels are the most valuable for shareholders and is positively related with firm performance.

Overall, our model documents a non-linear relationship between independence, expertise and firm performance that may explain the difficulty to reach a clear cut evidence on the independence-performance nexus. Our results are consistent with empirical studies showing that firm value is related to the share of independent

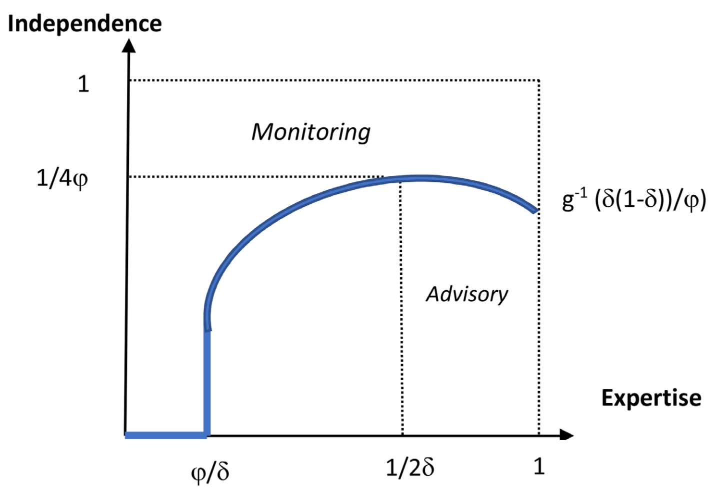

Figure 3. Board type depending on independence and expertise levels when $2 < 1/\varphi \leq 4$.

expert directors inside the boardroom (Wang et al., 2015; Faleye et al., 2018). These firms would belong to the set of companies with a monitoring board at high levels of expertise (right top corner on **Figure 2**). The model is also consistent with Dass et al. (2014) who show a positive association between expert boards and firm performance. Indeed, the model shows that firm performance increases with the level of expertise if the board is able to effectively discipline managers. This model enables to reconciliate some diverging empirical results by mapping different board behaviors (advisory and monitoring) depending on the expertise and independence levels. It shows also the necessity to train independent directors, notably on extra-financial issues, to improve corporate performance, as suggested by Crifo et al. (2018).

4. Empirical Estimations on French Data

This section provides empirical evidence to support the predictions of our model in the French context.

4.1. Data

Our empirical analysis is based on a matched data set from three sources: Ethics & Boards, Thomson One Banker and Infinancials, and for firms belonging to the SBF120 index (the 120 largest listed firms by market capitalization and by trading volumes in 2011 on NYSE-EURONEXT Paris[1]) over the 2006-2011 period. Ethics & Boards, an international board watching agency, provides information on board composition and directors characteristics for French listed firms. Infinancials gives comprehensive financial data and Thomson One Banker document the ownership structure. After matching those three sources of data, 113 among the 120 largest French listed companies (SBF120) make up the sample. The unbalanced final panel comprises 618 firm-level observations over the 2006-2011 period. **Table 1** provides the definition of board and firm variables.

Ethics & Boards database provides board composition and board-related information for directors such as status (insider, independent, or employee's representative) and functions (Chairman, Chief Executive Officer, CEO, executive). The database also includes individual characteristics such as gender, nationality, date of birth, education and previous and current professional activities. The missing information has been completed by hand collection from annual reports and internet searches (Who's who, linkedin...). We categorize an individual as an insider, an affiliated or an independent board member. We use the standard AFEP/MEDEF[2] code definition[3]: independence is assumed to be compromised if

[1]Firms are included in the sample if they belonged to SBF120 index in January 2011. The sample of firms is then stable over the period in order to avoid selection bias due to index exclusion or entrance.

[2]AFEP (Association Française des Entreprises Privées) and MEDEF (Mouvement des Entreprises De France) are two associations representative of the private business sector at the national level.

[3]Firms are allowed to adopt a "comply or explain" approach. Most of firms apply all criteria of independence. We take here firm disclosure in order to evaluate the impact of independence as defined by practitioners. We do not take into account stricter definition of independence Crespi-Cladera and Pascual-Fuster (2014) (for discussion).

Table 1. Definition of variables.

Variables	Description
Panel A: Board characteristics	**Ethics & Boards**
Board Size	Size of the board
% Women	Share of women
% Foreigners	Share of foreign directors
% of Busy Directors	Proportion of directors who have at least one other directorship during the same year in the SBF120 index
% of Young Directors	Proportion of directors who are less than 45 years old
% Independent	Share of independent directors (according AFEP-MEDEF code of corporate governance)
% Insider	Share of executive directors
% Industry Expert	Share of industry expert directors
% Industry Expert Independents	Proportion of industry expert independent directors
Supervisory Board	Dummy equal to 1 if corporate governance is a two tier board
Chair/CEO separation	Dummy equal to 1 if chairman and CEO are two distinct persons
Panel B: Firm characteristics	**Infinancials & Thomson One Bankers**
Nb employees	Number of employees
Ownership Float	Share of ownership which is held by significant shareholders (each shareholder should hold at least 5% of the capital)
MTBV	Market to book value
Prox volatility	Stock volatility measures as the standard deviation of the monthly stock returns over the previous 50 months
RDonSales	Research and development expenses on total sales
Leverage	Leverage equal to total debt over total equity
ROA (Return on Assets)	Equal to the ratio between EBITDA (earnings before interest, taxes, depreciation and amortization) and beginning-year total assets
ROE (Return on Equity)	Equal to the ratio between net income and total equity

Note: This table describes the board and firm variables. Board characteristics are provided by Ethics & Boards. Firm characteristics are provided by Infinancials, except ownership structure by Thomson One Bankers.

the director of a company 1) is or has been, within the previous five years, a corporate executive or an employee of that company or of its affiliates; 2) is employed as an executive of another company where any of that company's executives sits on the board; 3) has been a director of the company for more than twelve years; 4) is a representative of a large blockholder (with at least 10% of stocks or voting rights); 5) has a significant business relationship with that company or its affiliates (as customer, supplier, banker or auditor); or 6) is related by close family ties to an executive director. We use past or current professional experience to define financial and extra-financial expertise (Anderson et al., 2011; Dass et al., 2014). A director is then defined as an industry-expert if the director has professional experience in the same industry. The accumulation of experience over the period is proxied through tenure (board experience) and age (professional experience) (Masulis & Mobbs, 2011, 2014). We define the following board structure and composition variables: board size (Yermack, 1996; Coles et al., 2008), supervisory board (two-tier board), Chairman/CEO separation (Belot et al., 2014), average board tenure (Vafeas, 2003; Huang, 2013), the proportion of busy directors (with at least one other seat the same year in our sample period) (Fich & Shivdasani, 2006; Field et al., 2013; Falato et al., 2014), and the proportion of young directors aged under 45 (Anderson et al., 2011).

Regarding firm characteristics, we follow the literature by controlling for a set of variables likely to be correlated with firm performance and board structure (Masulis et al., 2012; Wintoki et al., 2012). We control for size (proxied by the number of employees, in log) as well as financial leverage, measured as total debt over total equity. To proxy for the propensity of the firm to innovate and to accumulate intangible capital, we use the ratio of R&D expenditures over total sales. We control for long run stock price volatility, a proxy for firm risk, measured as the standard deviation of the monthly stock returns over the previous 50 months. We also control for ownership structure, with the share of outstanding shares held by significant owners (defined as owner with 5% or more of the equity capital). Finally, we control for market-to-book ratio, as a proxy for growth opportunities. Regarding firm performance, we use two different measures in all our regressions as a way to test the robustness of our results: Return On Equity (ROE) and Return On Assets (ROA). To avoid reducing the sample size in the regressions, we set missing values of both variables equal to zero and include for each variable a dummy that equals one if the information is available, and zero otherwise. Those dummies allow the intercept term to capture the mean of both variables for missing values.

4.2. Econometric Strategy and Results

In order to test the relationships between board composition and firm performance, we estimate multivariate regressions using panel data methods (Wintoki et al., 2012). The unbalanced nature of our panel implies the presence of heteroscedasticity: the variance of the error term depends on the number of times each firm is observed in time. We therefore perform robust regressions with clusters, in which observations are clustered by firm and the variance-covariance matrix is estimated using the Huber-White estimator. One issue with a simple OLS model is that estimates may be flawed by endogeneity related to unobserved heterogeneity across companies. A typical example is the competence of the managerial team that is hardly captured by observable factors: it is likely that this competence influences both firm performance and board composition. As it is now standard in the literature, we control for unobserved (time-invariant) heterogeneity at the firm level by including firm fixed effect in our regression models. We estimate the following equation:

$$y_{i,t} = \alpha X_{i,t} + \beta Z_{i,t} + \eta_i + \mu_t + \varepsilon_{i,t} \quad (4)$$

where $y_{i,t}$ is the performance of firm i at time t, $X_{i,t}$ is a vector of board composition variables (share of independents, insiders, industry experts, women, foreigners, busy directors, young directors, board tenure, separation between CEO and chairman positions, supervisory board and board size), $Z_{i,t}$ is a vector of (other) firm characteristics (log of number of employees, leverage, R&D investment on Sales, stock volatility, market to book ratio, ownership float), η_i is a firm fixed effect, μ_t a time dummy and $\varepsilon_{i,t}$ an error term.

Table 2 presents estimation results, for ROA (models 1 to 5) and ROE (models 6 to 10).

Table 2. Empirical relationships between board composition and firm performance.

Variables	(1) ROA	(2) ROA	(3) ROA	(4) ROA	(5) ROA	(6) ROE	(7) ROE	(8) ROE	(9) ROE	(10) ROE
% Independents	−0.031	0.094	0.103	0.096	−0.007	−0.074	0.222	0.232	0.220	−0.542*
	(0.024)	(0.060)	(0.064)	(0.060)	(0.082)	(0.082)	(0.203)	(0.192)	(0.188)	(0.287)
% Independents (square)		−0.132**	−0.134**	−0.136**	−0.101		−0.311	−0.314	−0.324	−0.067
		(0.061)	(0.063)	(0.059)	(0.061)		(0.214)	(0.212)	(0.207)	(0.200)
% Experts			0.019	−0.224***	−0.320***			0.024	−0.568*	−1.294***
			(0.027)	(0.085)	(0.115)			(0.105)	(0.309)	(0.440)
% Experts (square)				0.213***	0.246***				0.516**	0.772***
				(0.071)	(0.077)				(0.236)	(0.259)
% Independents × Experts					0.123*					0.907***
					(0.073)					(0.329)
% Insiders	0.001	0.019	0.015	−0.001	0.003	0.093	0.134	0.130	0.091	0.114
	(0.048)	(0.049)	(0.048)	(0.050)	(0.049)	(0.145)	(0.154)	(0.159)	(0.162)	(0.153)
Observations	618	618	618	618	618	616	616	616	616	616
Nb of firms	113	113	113	113	113	113	113	113	113	113
Board controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2-adj	0.196	0.203	0.203	0.234	0.238	0.105	0.108	0.107	0.124	0.148

Notes: (1) Dependent variables: Return On Assets (columns 1 to 5) or Return On Equity (columns 6 to 10). (2) Board variables include % of independent directors, % of industry expert directors, and the related interaction terms, % of insiders. (3) Board controls include % of women, % of foreigners, % of busy directors (with at least one other directorship the same year),% of young directors (age under 45), average board tenure (in log), a dummy that takes the value 1 in case of separation between CEO and chairman positions in a one-tier board (0 otherwise), a dummy that takes the value 1 in the case of a two-tier board (Supervisory Board) and board size. (4) Firm controls include size (number of employees, in log), MBTV (market to book value), financial leverage, R&D on sales, stock price volatility, % of float ownership. (5) Models include firm and year fixed effects. (6) Robust standard errors, clustered on firm, in parentheses. (7) Significance: ***p < 0.01, **p < 0.05, *p < 0.1.

Models 1 and 6 on Table 2 test the direct relationship between board independence and firm performance. The correlation is negative but not significantly different from zero, suggesting that board independence does not have the straightforward expected effect on firm decisions and performance. Models 2 and 7 introduce a non-linear relationship between the share of independent directors and firm performance. For the ROA, the square term is significantly negatively related to firm performance, suggesting a decreasing marginal benefit of independence. The empirical evidence thus suggests a decreasing marginal effect of independence as assumed in the model. It confirms that a non-linear relationship should be taken into account.

However, the theoretical model shows that directors' expertise may impact boards' decision and firm performance. In models 3 and 8, we add the share of industry experts inside the boardroom as a proxy of board expertise. There is no significant correlation. However, when introducing the square of the share of industry experts (models 4 and 9), there are negative correlations between expertise and firm performance and positive ones between the square term and performance for both ROA and ROE. These results highlight the non-linear pattern suggested by the model and reinforce the hypothesis of a disciplining effect of expertise. The negative first order part is consistent with the model, with the fact that below the expertise threshold, there is no effective impact of expertise on firm performance.

Finally, to test the joint effect of independence and expertise which should lead to the best firm performance (prop. 1), we introduce the share of industry expert independent directors (models 5 and 10). The coefficient is positive and significant for both ROA and ROE. It confirms that firms that are able to hire directors that are both independent and expert have the best performance.

These empirical results are consistent with the theoretical predictions, in particular the non-linear relationships between independence, expertise and firm performance, and confirm that expertise appears as a complex mediating factor between independence and firm performance.

5. Conclusion

A vast literature on corporate governance characterizes board functioning with a strategic communication model (Crawford & Sobel, 1982; Harris & Raviv, 2005) and successfully demonstrates that an independent board is not always optimal (Raheja, 2005; Adams & Ferreira, 2007; Harris & Raviv, 2008; Wagner, 2011). Following the contribution of Baldenius et al. (2014), we propose to separate the board monitoring and advisory functions to understand the complex relationship between board composition and performance. In particular, we investigate the monitoring-advising trade-off depending on the level of independence and expertise inside the boardroom. In our model, board may choose to be either monitoring or advisory towards the CEO. Three main results are derived. First, we show that the board's incentives to adopt a high monitoring level are non-monotonically (negatively and then positively) related to the expertise level. Second, the incentives for an advisory board to discipline the CEO are increasing with expertise, if the business has high opportunity for growth. And third, under specific parameter values, we show that there may be a disciplining effect of expertise in the sense that the more expert the board, the less opportunistic the CEO. Finally, we provide some empirical evidence to illustrate the non-linear relationship between board independence and expertise on the one hand and firm performance on the other hand.

Several areas left unexplained in this paper would be worth investigating in future research. First, our model assumes a simple relationship between board monitoring and board composition in the sense that the independence level affects the efficiency of board performance in monitoring board only, while expertise affects the efficiency of board performance in advisory boards only. It would be interesting to consider that expertise and independence affect board performance for both types of monitoring behaviors. Similarly, we assume that independence is homogeneously distributed for each level of expertise. However, the empirical literature shows most of the time a trade-off between independence and expertise among directors and some supply shortage regarding directors who hold both characteristics (Knyazeva et al., 2013). It would thus be interesting to introduce in the model a more complex director labor market and analyze the consequences on the different equilibria. It may worsen the disciplining effect of expertise and favor CEO's opportunistic behavior. Finally, this model could be adapted to integrate the Environmental and Social issues in order to investigate the monitoring-advising trade-off on the firm's sustainability performance (Burke, 2022; Amin et al., 2020; Harjoto & Wang, 2020; Naciti, 2019; Birindelli et al., 2018).

Acknowledgements

Support from Research program "Investissements d'Avenir" (ANR-11-IDEX-0003/Labex Ecodec/ANR-11-LABX-0047) and from the research center for Sustainable Finance and Responsible Investment (IdR FDIR, Ecole Polytechnique and TSE IDEI: http://fdir.idei.fr/en/) is gratefully acknowledged.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

A.1. Description of the Productive Stage

In the production stage, we consider an economy composed of two industries: a final good industry and an intermediate goods industry. Intermediate goods are used as factors of production in the final good industry. The final good is produced using two different types of intermediate goods: The goods produced by continued firms (labelled c) and the goods produced by restarted firms (labelled r).

The production function is a Cobb-Douglas:

$$y = \left(x_c\right)^{\alpha}\left(x_r\right)^{1-\alpha} \tag{5}$$

where y is the final good production in a competitive environment using both continued firms' goods, x_c, and restarted firms' goods, x_r, and where α, the final good elasticity related to the continued goods, $0 < \alpha < 1$.

The profit maximization problem by a representative firm in this industry leads to the following inverse demand for inputs:

$$p_c = \partial y/\partial x_c = \alpha\left(x_c\right)^{\alpha-1}\left(x_r\right)^{1-\alpha} \tag{6}$$

$$p_r = \partial y/\partial x_r = (1-\alpha)\left(x_c\right)^{\alpha}\left(x_r\right)^{-\alpha} \tag{7}$$

where p_c denotes the price of continued firms' goods and p_r the price of restarted firms' goods. Consequently, the equilibrium price of each intermediate good, x_c and x_r, is given by its marginal product.

Intermediate goods are used to produce the final good according to a one-for-one technology. In particular, it is assumed that x units of final good requires x units of intermediate goods. Given the inverse demand for intermediate goods in the final good sector (Equations (6) and (7)), the optimization program for continued firms, c, and for restarted firms, r, is given by:

$$\max_{x_c} p_c x_c - x_c = \alpha\left(x_c\right)^{\alpha}\left(x_r\right)^{1-\alpha} - x_c \tag{8}$$

$$\max_{x_r} p_r x_r - x_r = (1-\alpha)\left(x_c\right)^{\alpha}\left(x_r\right)^{1-\alpha} - x_r \tag{9}$$

from where we obtain the profit-maximizing prices and the flow of profits for each type of business:

$$\begin{aligned} p_c &= 1/\alpha \\ p_r &= 1/(1-\alpha) \\ V_c &= (1-\alpha)x_c/\alpha \\ V_r &= \alpha x_r/(1-\alpha) \end{aligned} \tag{10}$$

A.2. Solving the Equilibrium

A.2.1. Analysis of the Model for a Given Degree of Board Independence, I

At date 0, the board chooses a complex (H-type) rather than routine (L-type) project, if and only if, given the expertise and independence levels E and I, the expected payoff from a H-type firm is higher than the expected payoff from a L-type firm, conditional upon continuing the project in period 2, that is:

$$\bar{\pi}^H \geq \bar{\pi}^L \Leftrightarrow B^H \geq B^L \Leftrightarrow a^H m^H \geq a^L m^L \Leftrightarrow \varphi g(I) \geq \delta E(1-\delta E)$$

Since function $g(.)$ is continuous and strictly increasing, the inverse function g^{-1} is also continuous and strictly increasing. To guarantee that the project's probability of success m^H is always lower than 1, we assume that φ is lower than 1/4 (coexistence constraint). Otherwise, the board would always choose the routine-low monitoring project (L-type).

In turn, inequality $\varphi g(I) \geq \delta E(1-\delta E)$ implies that there is a unique threshold level of independence, I^* such that $0 < I^* < 1$, which equalizes the firm's expected profit from both H and L-type projects $\bar{\pi}^H(I^*) = \bar{\pi}^L(I^*)$ where:

$$I^* = g^{-1}\left(\frac{\delta E(1-\delta E)}{\varphi}\right) \tag{11}$$

The decision rule is thus such that boards with a degree of independence above the threshold I^* choose the complex-high monitoring, project (H-type), while boards with a degree of independence below I^* choose the routine-low monitoring project (L-type).

Note that when the level of expertise E is lower than $E^* = \varphi/\delta$, the level of expertise is too low to be beneficial, the parameters are always such that $a^H > a^L$ and the board always find it beneficial to choose a routine project (L-type). We now analyze the model when the degree of board expertise is either above ($E > E^*$) or below this threshold ($E < E^*$).

A.2.2. Solving the Model for a High Degree of Board Expertise, E

We assume that $E > E^* = \varphi/\delta$. We solve the model by backward induction.

Resource constraints

In period 2, we can distinguish three categories of firms: firms with L-type project that continue the initial project, firms with H-type project that continue the initial project and firms that launch a new project. The firm population mass is normalized to one. The firm type (H or L) depends on the degree of independence and expertise of the board. Let $\mu(I, E)$ denotes the cumulative distribution function of firms with independence degree I conditional on expertise degree E. f is the related density function. Then the distribution function is defined by:

$$\mu(I,E) = \int_0^\gamma f(x,E)\,\mathrm{d}x \tag{12}$$

Because the population is normalized to one, we make the following assumption: $\forall E, \mu(1, E) = 1$

We have seen that the board chooses the complex-high monitoring (H) project if the independence degree I is higher than the threshold I^*. The share of routine-low monitoring (L) firms hence is given by $\mu(I^*, E)$ and the share of complex-high monitoring (H) firms is given by $1-\mu(I^*, E)$.

Let denote by $\bar{H}$ (resp. $\bar{L}$) the share of H-type (resp. L-type) firms whose board chooses to continue the initial project, by $\overline{n}^{\theta}$ the number of θ-type firms who continue the project and by $\underline{n}$ the number of firms who start a new project. Since the number of firms is normalized to 1, the resource constraints then write:

$$\overline{n}^{H}+\overline{n}^{L}+\underline{n}=1 \text{ with } \begin{cases} \overline{n}^{H}=\left(1-\mu\left(I^{*},E\right)\right)\overline{H} \\ \overline{n}^{L}=\mu\left(I^{*},E\right)\overline{L} \\ \underline{n}=\left(1-\mu\left(I^{*},E\right)\right)\left(1-\overline{H}\right)+\mu\left(I^{*},E\right)\left(1-\overline{L}\right) \end{cases} \quad (13)$$

Restarting project decision

We now consider the firm's decision to continue the initial project or to abandon it and to launch a new one at date 1. A θ-type project is continued as long as it provides a higher utility for the CEO, that is $\beta_c\overline{\pi}^{L}<\beta_c\overline{\pi}^{H}$ (see Equation (1)). In equilibrium, since the probability of success of λ^{H} is always higher than λ^{L}, this condition is only binding for advisory (L-type) projects.

Restarting decisions in turn satisfy the following rule:

$$\beta_c\underline{\pi}+\underline{\lambda}\psi=\beta_c\overline{\pi}^{L}<\beta_c\overline{\pi}^{H} \quad (14)$$

where $\underline{\pi}$ and $\overline{\pi}^{\theta}$ are defined by Equation (3).

This rule implies that CEOs with a complex-high monitoring (H) project always choose to continue the project, and CEO with a routine-low monitoring (L) project are indifferent between continuing or restarting, that is:

$$\overline{H}=1 \text{ and } \beta_c\overline{\lambda}^{L}\frac{1-\alpha}{\alpha}\overline{x}=\beta_c\underline{\lambda}\frac{\alpha}{1-\alpha}\underline{x}+\underline{\lambda}\psi \quad (15)$$

The continued goods ($\overline{x}$) are produced by all firms with a complex-high monitoring project and some of the firms with a routine-low monitoring project whereas restarted goods ($\underline{x}$) are produced by some firms with routine-low monitoring project. Taking into account the resource constraints (13), the market clearing condition then writes:

$$\begin{aligned}\overline{x}&=\int_{I^{*}}^{1}\overline{\lambda}^{H}\overline{H}f\left(I,E\right)\mathrm{d}I+\int_{0}^{I^{*}}\overline{\lambda}^{L}\overline{L}f\left(I,E\right)\mathrm{d}I\\&=\int_{I^{*}}^{1}g\left(I\right)\overline{\lambda}^{H}f\left(I,E\right)\mathrm{d}I+\overline{\lambda}^{L}\overline{L}\mu\left(I^{*},E\right)\end{aligned} \quad (16)$$

$$\underline{x}=\int_{0}^{I^{*}}\underline{\lambda}\left(1-\overline{L}\right)f\left(I,E\right)\mathrm{d}I=\underline{\lambda}\left(1-\overline{L}\right)\mu\left(I^{*},E\right) \quad (17)$$

Substituting for (16) and (17) into (15) finally allows to determine the share $\overline{L}$ of firms with a routine-low monitoring (L) project who chooses to continue the project:

$$\overline{L}=\frac{\kappa^{2}\frac{\alpha}{1-\alpha}+\frac{\frac{\psi\kappa}{\beta_c}-\frac{1-\alpha}{\alpha}\int_{I^{*}}^{1}g\left(I\right)\overline{\lambda}^{H}f\left(I,E\right)\mathrm{d}I}{\lambda\left(1-\delta E\right)\mu\left(I^{*},E\right)}}{\frac{1-\alpha}{\alpha}+\kappa\frac{\alpha}{1-\alpha}} \quad (18)$$

In this ratio, $\frac{\psi\kappa}{\beta_c}$ is the difference between the value of a successful continued project and a restarted project from the shareholder perspective in a L-type firm and $\frac{1-\alpha}{\alpha}\int_{I^*}^{1} g(I)\bar{\lambda}^H f(I,E)\,\mathrm{d}I$ is the value of the initial project in a H-type firm which effectively produces the initial good (in equilibrium). Finally, $\lambda(1-\delta E)\mu(I^*,E)$ is the expected share of successful L-type firms without managerial opportunism (i.e. firms with low-monitoring boards which effectively produce goods without CEO opportunistic behavior).

The share of continued firms with low-monitoring boards can thus be rewritten as:

$$\bar{L} = \frac{\kappa^2 \frac{\alpha}{1-\alpha} + \frac{\bar{V}^L - \underline{V}}{\lambda(1-\delta E)\mu(I^*,E)}}{\frac{1-\alpha}{\alpha} + \kappa^2 \frac{\alpha}{1-\alpha}} \tag{19}$$

$$\text{with } \bar{V}^L - \underline{V} = \bar{V} - \underline{V} - \frac{1-\alpha}{\alpha}\int_{I^*}^{1} g(I)\lambda f(I,E)\,\mathrm{d}I \tag{20}$$

The share of L-type firms which continue the initial project is then directly related to the value gap between producing the continued and the restarted goods for the L-type firms. This value gap depends on the degree of board expertise *E*. The share of L-type firms which prevent managerial opportunism (i.e. prevent the CEO from restarting a new project at the production stage) is then impacted by the board expertise degree.

A.2.3. Solving the Model for a Low Degree of Board Expertise, *E*

We now consider the case $E \le E^* = \varphi/\delta$, when the expertise level is too low to make the advisory function beneficial enough to the shareholders, and the board always chooses a high monitoring level (*H*). In this case, the number of firms with a routine -low monitoring project is null. The resource constraints then become:

$$\bar{n}^H + \underline{n} = 1 \quad \text{with} \quad \begin{cases} \bar{n}^H = \bar{H} \\ \underline{n} = 1 - \bar{H} \end{cases} \tag{21}$$

CEOs with a monitoring (*H*) board choose to continue the project as long as the expected payoff is higher than that of the restarted project: $\beta_c \bar{\pi}^H > \beta_c \underline{\pi} + \underline{\lambda}\psi$ (see Equation (1)). In equilibrium, this condition is binding which implies that some firms with a monitoring (*H*) board which continue the initial project satisfy the following indifference condition: $\beta_c \bar{\pi}^H = \beta_c \underline{\pi} + \underline{\lambda}\psi$. We know that for a fixed level of expertise, the expected payoff is increasing with the level of independence ($\bar{\lambda}^H$ increases with *I*), therefore CEOs who decide to abandon the initial project and restart a new one are those with the lowest degrees of board independence.

Let denote by I^{**}, the new threshold of independence below which the CEO decides to restart a new project when $E \le \varphi/\delta$. Restarting decisions in turn satisfy the following rule:

$$\beta_c \bar{\pi}^H \left(I^{**}\right) = \beta_c \underline{\pi} + \underline{\lambda}\psi \quad (22)$$

CEOs with a monitoring (H-type) board are indifferent between continuing or restarting if:

$$\beta_c \bar{\lambda}^H \frac{1-\alpha}{\alpha} \bar{x} = \beta_c \underline{\lambda} \frac{\alpha}{1-\alpha} \underline{x} + \underline{\lambda}\psi \quad (23)$$

Given the resource constraint (21), the market clearing condition then writes:

$$\begin{aligned} \bar{x} &= \int_{I^{**}}^{1} \bar{\lambda}^H f\left(I,E\right) \mathrm{d}I \\ \underline{x} &= \int_{0}^{I^{**}} \underline{\lambda} f\left(I,E\right) \mathrm{d}I \end{aligned} \quad (24)$$

Substituting for (24) into (23) finally gives the share $\bar{H}$ of firms with a high monitoring board which choose to continue the initial project:

$$\bar{H} = 1 - I^{**} \text{ such that } \bar{x}\left(\frac{1-\alpha}{\alpha} - \frac{\kappa\alpha}{1-\alpha}\frac{\underline{x}}{\bar{x}}\right) = \frac{\kappa\psi}{\beta_c} \quad (25)$$

Note that $\bar{H}$ is independent of the level of expertise *E*. There is no incentive to marginally increase the level of expertise in this case (below the expertise threshold).

A.2.4. Participation and Incentive Compatibility Constraints

Shareholders maximize the profits from their initial investment $1. At the beginning of period 1 ($t = 0$), shareholders decide to create the firm (and finance the project) if and only if the expected return is at least equal to their initial investment (participation constraints). If shareholders receive a repayment lower than the initial investment, they refuse to finance the CEO's project.

The board and the shareholders' interests are aligned because both receive a share of the firm's profit. As developed previously, the board hence chooses the monitoring level by maximizing profits, as shareholders would do. At the end of the governance stage, the board decides to accept the initial project if its net present value is positive after the payment of the CEO compensation (incentive compatibility constraints). The net present value of the project should then satisfy:

$$\left(1 - \beta_c - \beta_b\right) \bar{\lambda}^\theta \bar{V}^\theta > 1 \quad (26)$$

The interest of the CEO and the CEO participation and incentives constraints are directly related to the expected payoff. The CEO participation constraints impose that β_c is strictly positive as well as the firm cash flow (verified by the model assumption). Two conditions allow determining the optimal level of CEO compensation, at the industry level and from the shareholders' perspective, that prevents managerial opportunism i.e. CEO's choice of restarting a project at the production stage (incentive compatibility constraints). β_c should be determined so as to verify both incentive compatibility constraints. It depends on the value of the private benefit driven from the implementation of the restarted project ψ.

When $E > \varphi/\delta$, the first condition is the incentive compatibility constraint ensuring that the share of firms with an advisory (L-type) board whose the CEO chooses to continue the initial project is strictly positive:

$$\mu\left(I^*, E\right)\bar{L}\bar{\lambda}^L \beta_c \bar{V} > \mu\left(I^*, E\right)\left(1-\bar{L}\right)\underline{\lambda}\left(\beta_c \underline{V} + \psi\right) \tag{27}$$

When $E \leq \varphi/\delta$, the second condition is the incentive compatibility constraint ensuring that the share of firms with a monitoring (H-type) board whose the CEO chooses to continue the initial project is strictly positive:

$$\bar{\lambda}^H \bar{H} \beta_c \bar{V} > \underline{\lambda}\left(1-\bar{H}\right)\left(\beta_c \underline{V} + \psi\right) \tag{28}$$

A.3. Proof of Proposition 1

The proof is made for a general set of functions $g(.)$.

Note that function $g(.)$ is continuous and strictly increasing. Then, the inverse function, g^{-1} is also continuous and strictly increasing. From Equation (11), we get

$$\frac{\partial I^*}{\partial E} = g^{-1\prime}\left(\frac{\delta E\left(1-\delta E\right)}{\varphi}\right)\frac{\delta}{\varphi}\left(1-2\delta E\right) \tag{29}$$

where $g^{-1\prime}(.) > 0$.

The share of advisory (L-type) boards (low monitoring board), equal to I^*, increases when $\varphi/\delta < E < 1/2\delta$ if $1/\varphi$ is higher than 2, and decreases when $E > 1/2\delta$ whatever the value of φ. At $E = 1/2\delta$, the share of L-type boards is $1/4\varphi$. Then $1/\varphi$ should not be higher than 4 in order to keep I^* under 1.

Given that the share of boards that choose to be H-type (high monitoring board) is equal to $1-I^*$, we have

$$\frac{\partial\left(1-I^*\right)}{\partial E} > 0 \Leftrightarrow \left(1-2\delta E\right) < 0 \tag{30}$$

Then the number of monitoring (H-type) boards, equal to $1-I^*$, decreases when $E < 1/2\delta$ if $1/\varphi$ is higher than 2, and increases when $E > 1/2\delta$ in any case. At $E = 1/2\delta$, the share of monitoring (H-type) boards is $1-1/4\varphi$.

Note that if $1/\varphi$ is lower than 2, the share of advisory (L-type) boards is decreasing from φ/δ to 1. The share of monitoring boards is increasing.

A.4. Proof of Proposition 3

The share of advisory boards who choose to continue the initial project is given by Equation (18): $\bar{L} = \dfrac{\kappa^2 \dfrac{\alpha}{1-\alpha} + \dfrac{\dfrac{\psi\kappa}{\beta_c} - \dfrac{1-\alpha}{\alpha}\int_{I^*}^{1} g(I)\bar{\lambda}^H f(I,E)\mathrm{d}I}{\lambda\left(1-\delta E\right)\mu\left(I^*,E\right)}}{\dfrac{1-\alpha}{\alpha} + \kappa\dfrac{\alpha}{1-\alpha}}$. We thus have:

$$\frac{\partial \bar{L}}{\partial \psi} = \frac{\kappa}{\beta_c \left(\lambda\left(1-\delta E\right)\mu\left(I^*, E\right)\right)\left(\frac{1-\alpha}{\alpha} + \kappa \frac{\alpha}{1-\alpha}\right)} > 0$$

The partial derivative of the share of advisory (L) firms relative to ψ is always positive.