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Abstract

In this paper, I study how the CEO's election can be biased if some directors in the board belong to the same network. I use a static Bayesian game. Directors want to elect the best candidate but they also want to vote for the winner. In that context, results show that, when no candidate is part of the network, boards with a network perform better in electing the right candidate. On the other hand, it becomes detrimental for stockholders if one candidate is part of the network. Indeed, compared to a situation where there are no interconnections between directors, the directors who are members of a network vote more often for the candidate they think is best, rather than for the one they think might win. The ones who are not part of the network follow their lead. Thus the network has power on the result of the election and therefore limits the power of the future CEO.
Keywords: Networks, corporate governance

JEL Classification Numbers: D71, G34, Z13

Résumé

Cet article étudie, en utilisant un jeu Bayésien statique, comment l'élection du Président de Conseil d'Administration peut être biaisée si certains administrateurs appartiennent à un même réseau. Les administrateurs veulent élire le meilleur candidat mais ils souhaitent également avoir voté pour le futur vainqueur. Dans ce contexte, les résultats montrent que, quand aucun candidat ne fait partie du même réseau que les administrateurs, les conseils d'administration avec de tels réseaux sont bénéfiques pour les actionnaires. Les résultats s'inversent si un candidat fait partie du réseau. En effet, comparés à une situation dans laquelle les administrateurs ne sont pas liés les uns aux autres, les administrateurs qui font partie d'un réseau sont davantage susceptibles de voter pour le candidat qu'ils jugent meilleur que pour celui dont ils pensent qu'il va gagner. Les administrateurs hors du réseau se rallient alors à ce vote. Le réseau apparaît comme un contre-pouvoir face au futur Président de Conseil d'Administration et pèse en ce sens dans l'élection.
Mots clés: Réseaux, gouvernance d'entreprise

Codes JEL: D71, G34, Z13

1 Introduction

In his *History of the Peloponnesian War*, Thucydides recounts the preparation of the Sicilian campaign. He pictures the opposition between Nicias, the older, prudent man and Alcibiades, the young and imprudent one. The citizens need to elect a general but what they are really voting for is a strategic choice : peace with Nicias or war with Alcibiades. Both men make a speech defending their points of view but it appears quickly that Alcibiades makes a bigger impression than Nicias and the citizens elect him, by a show of hand (as was customary in Athens). Interestingly enough, Thucydides reports : "With this enthusiasm of the majority, the few that liked it not, feared to appear unpatriotic by holding up their hands against it, and so kept quiet". Alcibiades gets elected for three reasons: many citizens liked the idea of going to war, he was more brilliant than Nicias and few people wished to utter their opposition in the context where it appeared he would win the election.

The election of the Chairman of a board or a CEO bears similarities with that of Alcibiades. Candidates are more or less talented and they present strategic options for the firms. Board members have their own opinions as to what the strategy should be, they are looking for a talented leader but also, none of them wants to be a "black sheep" who voted against the elected Chairman. In this context, ties between board members could be important. Indeed, if a subgroup of them shares the same opinion on the right strategy and the right candidate, it has an impact on the election. This is the hypothesis I study in this paper. Using a static Bayesian game borrowed from Levy (2007a), I explore how ties between some board members affect every director's vote. The results show that, if directors are not biased towards the winner, then directors who are not part of the network are not affected by the existence of such network. But if we consider that directors are indeed biased towards the winner, then all directors are affected by the network.

In the case of Athens, the election of Alcibiades was a disaster since the Sicilian expedition led to a military defeat, a renewed war with Sparta and eventually the oligarchic coup of 411 BC. In the corporate boards, the effect on the firm's owners is not as obviously detrimental. The bias towards the winner is always detrimental but a network among some board members can produce desirable effects. In particular, when no candidate is part of that network, the existence of ties between some board members can limit the bias to vote for the winner and lead all directors to express their opinions. On the other hand, when one candidate is part of the network, then, it is detrimental to the firm's owners. These effects on the firm's value show that ties between board members have an effect. This could lead to reassessing the effect of directors' independence or at least to broaden the definition of "independence".

To analyze this question, after a quick literature review (**section 2**), I set up a model where directors are biased towards the winner but in which they are not tied to one another (**section 3**). I call this the "benchmark case" and show in (**section 4**) that the bias distorts votes compared to the case where directors are only concerned about voting for the best candidate. After that, I introduce ties between two board members out of three. This is the network. All directors are biased towards the winner. The candidates can be out of the network (**section 5**) of part of it (**section 6**). I then estimate the "welfare" of the firm's owners in all these situations (**section 7**).

2 Literature review

Interest for corporate governance has surged over the last decades. In many corporate scandals, the role of the board has been pointed out as critical. Consequently, guidelines regarding board composition have been issued by policy makers or by firms themselves. As a consequence, the proportion of independent directors has increased. Despite this attempt, the financial crisis and its aftermath has further brought suspicion onto boards and their regulatory powers, in particular regarding their control over compensations. Consequently, some advocate passing laws to limit such compensations or golden parachutes. Academic research on corporate boards has preceded and accompanied this movement of public interest.

The role of a board is to hire and fire top management, supervise it and set the strategy of the firm. Academic research has focused widely on the supervision, although hiring and firing of top management enter in these models. Theory papers mainly rely on agency theory. They advocate for the separation between the control and the management authorities (see Fama and Jensen (1983)). Dividing both authorities leads to ask the question of the board's independence. The theory predicts that firms with independent boards will better protect the interests of the owners. Empirical studies show conflicting results on this point: Westphal (1999) shows that indeed a more independent board fires more easily a poorly performing CEO but Boyd (1994) shows that an increased ratio of outside directors can be positively correlated with compensation. In these papers, independence is defined as a lack of formal link with the firm other than directorship. However, this definition is oblivious of two forms of dependence that might affect the votes: de facto dependence towards the Chairman and interdependence of board members. González (2006) looked into herding as a possible candidate for the contradictory results regarding the effect of outside directors.

To study further the hypothesis that directors' interdependence can affect the election process, I borrow a model from Levy (2007a) and Levy (2007b). This model studies voting behaviors in committees, with transparent voting. In these papers, Levy studies directors who are concerned about how they are going to be perceived by stockholders. I do not keep these reputation concerns in my model. However, I add a concern similar to a reputation concern: directors are concerned about how the future CEO is going to assess them. Very simply, the CEO judges positively a director who voted for him. In this set up, following Levy, I study the impact of correlation between board members. But I assume that only 2 out of 3 directors are correlated.

3 Benchmark case : a bias towards the winner but no network

This paper aims at studying the effect of networks in a board where directors have a dual concern: they want to vote for the winner and they want to elect the candidate they believe will make most out of the firm.

I assume that all candidates are directors and I only consider CEOs serving also as Chairmen. This could be relaxed but would make the model more complex and less tractable. I assume also that votes inside a board are transparent. This ensures that the elected CEO knows who voted for him and who did not with certainty, justifying that board members want to vote for the winner.

Directors also want to elect the best candidate. Each director, in his own field of interest, assesses a candidate by the yardstick of the strategy suggested by the candidate. Each director has his own opinion about which strategy is best. It is assumed that the composition of the board is optimal, i.e. aggregating the ideal strategy of each director would yield the best possible outcome. This hypothesis that directors choose a new CEO according to the strategy he will implement is consistent with results of empirical studies on boards, in particular Westphal and Fredrickson (2001).

3.1 The set up

I now describe the election process in a board. Consider a 5 member committee. Two members are candidates and vote for themselves. I am analyzing the votes of the three other members. This is the smallest possible board for my study because I want to introduce a network between some but not all members who are not candidates. I study how increasing the number of members affects the results in section 8 (it reinforces the results but does not alter them).

Each non candidate member i, $i \in \{1, 2, 3\}$ is assigned a random variable $w_i \in \{A, B\}$ that he does not observe directly. This w_i represents the candidate who is most in line with director i 's strategy in director i's field of interest. Without loss of generality, the probability that $w_i = B$ is $q > 1/2$. The prior is the same for all directors and is common knowledge.

Directors do not have a perfect knowledge of the candidate therefore they cannot have full information on w_i. They only receive a signal s_i on w_i.

Depending on their talent/ work as directors, this signal will be more or less accurate. Each expert receives the signal $s_i \in \{A, B\}$ such that $Pr(s_i = w_i) = t_i$ and t_i is uniformly distributed on $[0.5, 1]$. s_i and t_i are private information. The more talented directors are, the more they learn about the candidates, and the more they are able to assess which is best.

Directors know their own t_i so they can retrieve their own w_i from s_i with Bayesian updating.

$$v(q, s_i, t_i) \equiv Pr(w_i = A|q, s_i, t_i) = \begin{cases} \frac{(1-q)(1-t_i)}{qt_i+(1-q)(1-t_i)} & \text{if } s_i = B \\ \frac{(1-q)t_i}{q(1-t_i)+(1-q)t_i} & \text{if } s_i = A \end{cases} \tag{1}$$

Members A and B who are candidates, get respectively $w_A = A$ and $w_B = B$ and all board members observe that. The intuition of this is obvious: it is common knowledge that each candidate thinks he is the best suited for the job. Likewise, the candidates do not have the same utility function as the other members: they vote for themselves since their utility is obviously higher if they are elected than if their competition is.

All members simultaneously cast their vote $m_i \in \{A, B\}$. The decision of the committee is $D \in \{A, B\}$. The voting rule is a simple majority so $D = A$ if and only if $\{\#i|m_i = A\} > 2$ The board members are interested in who will be Chariman as he will lead the firm in one or the other direction. Their utility function is as follows:

$$u_i(D|w_i) \begin{cases} 1 & \text{if } D = w_i \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

This corresponds to the idea that directors have an intrinsic individual "best" candidate.

But the directors are also concerned about voting for the Chariman who wins. The CEO holds a large power over directors, especially when he acts as Chairman as shown by Adams, Almeida and Ferreira (2005). He decides over the composition of committees, plays a key role in the election of new members and can lead an elected member not to be reelected. Directors, whether independent or not, are reluctant to challenge the CEO. Mace (1971) found that those who challenge the CEO can be asked to resign. I assume a bias towards the winner in the following information function:

$$z_i(m_i|D) = \begin{cases} 1 & \text{if } m_i = D \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

The value function of the director is a convex combination of the two functions: $(1-G)u_i(D|w_i) + Gz_i(m_i|D)$. G can be seen as the importance the directors assign to the fact of voting for the winner. Since I normalize the payoffs of both functions u and z to 1 and 0, the only variation comes from G. When $G = 0$, directors care only about the decision and therefore vote efficiently. The timing of the game goes as follows:

1. The states of the world w_i are realized and each i learns s_i and t_i
2. Each board member casts simultaneously her vote m_i including the two candidates who vote for themselves. Each board member observe the others' votes
3. The decision of the committee is $D = A$ if $\{\#i|m_i = A\} > 2$, D=B otherwise
4. The values $u_i(D|w_i)$ and $z_i(m_i|D)$ are realized
5. The firm is dismissed

4 Analysis of the benchmark case : bias, no network

The case we want first to consider is one in which all directors are independent. The w_i's are not correlated. One cannot learn anything on his own w from the other's or anything on the others' w's from his own.

4.1 The efficient director – no bias and no network

In this case, directors' sole concern is to elect the candidate who is more in line with their interests ($G = 0$). They vote as if they were pivotal. Indeed, if they are not pivotal, their vote has no consequence on their utility. In that case, they vote efficiently.

Proposition 1 *When they are not concerned about voting for the winner, there exist a unique cut-off equilibrium* ($s^* = A, t^* = q$) *in which directors are efficient and vote for* A *if and only if* $s = A$ *and* $t > q$

Proof of proposition 1. All proofs are in the appendix. ■

The proof of proposition 1 is detailed in the appendix. Notice however that the key equality is:

$$v(q,s,t)u(A|w=A)+(1-v(q,s,t))(u(A|w=B)) = v(q,s,t)u(B|w=A)+(1-v(q,s,t))u(B|w=B) \tag{4}$$

This equates the payoffs when a director votes for A (left hand side) with payoffs when he votes for B (right hand side). Equality shows that the director is indifferent and this provides the cutoff value.

This proposition shows that the directors, when concerned about electing their best candidate, follow their signal to contradict the prior only if they consider that their ability is high enough to do so. The limit case is when $s = A$ and $t = 1$, in which case the signal provides perfect information. It is then efficient for the director to contradict the prior since he knows, for sure, that the best candidate is indeed A. In the case where $s = A$ and $t = 0.5$, the signal provides no information, it is therefore efficient for the director to choose the candidate favored by the prior and vote for B. The cut-off $t^*_{eff} = q$ makes sense. Indeed, if $t > q$ and $s = A$, then it means that the probability that $w = A$ is greater than the probability that $w = B$ by definition of q and t. It is thus efficient for a director to vote for A in that case and in that case only.

4.2 Introducing the bias to vote for the winner

When I introduce a bias towards the winner ($G \neq 0$), a director's vote affects his utility whether he is pivotal or not through function $z(.)$. Indeed, even when he is not pivotal, the future Chairman observes individual votes. A director therefore has to estimate his probability of being pivotal. He always votes for the winner when he is pivotal (by definition). On the other hand, when he is not, his vote does not have any effect on the result of the election, so he is only concerned in electing the winner.

Lemma 1 *There exists a unique cut-off value $v^*(q, s, t)$, corresponding to a unique pair (t^*, s^*) such that the director votes for A if $v(q, s, t) > v^*(q, s, t)$ and B otherwise.*

Let $P_i[piv]$ is the probability of director i being pivotal, $P_i[D|npiv]$ is the probability of D being elected given that director i is not pivotal (I drop the subscript for simplicity reasons).

Lemma 2 *If $s^* = A$, then $(1 - P[Piv])(P[A|nonpiv]) < (1 - P[Piv])P[B|nonpiv])$*

Lemma 3 *The only possible cut-off equilibrium admits $s^* = A$*

The lemma is intuitive in this case. The directors want to elect the candidate who is both the best and the most likely to being elected. Since the prior favors B, the a priori most likely one to be elected is B. When a director thinks he is pivotal, he acts efficiently and contradicts the prior only if his signal contradicts the prior and he is talented enough to follow that signal. If a director thinks he is pivotal and gets a signal B, he never contradicts his signal. If he does not think he is pivotal, a director looks at the prior to evaluate who is most likely to being elected (in this case B). So there is no reason why a director with signal B should vote for A when ws are not correlated.

Proposition 2 *When directors are concerned about voting for the winner, there exists a unique cut-off point equilibrium characterized by a pair $(s^* = A, t^*)$ such that if $s = A$ and $t > t_0^*(q)$, the director votes for A and B otherwise. $t > t_0^*(q) > q$ but bounded away from 1. This equilibrium exists for G low enough. When G is too high, $G > \bar{G}_0$, the only possible equilibrium is one in which all directors vote for B.*

(Notice that I use the subscript eff for the efficient case and 0 for the benchmark case)

An efficient director (no bias, $G = 0$) director goes against the prior only if he is talented enough. In the benchmark case (bias, no network), this still holds for the case in which the director votes as pivotal. With the probability that he is not pivotal, his own signal, even if it is perfectly accurate, does not inform him on the outcome of the election since the w_is are note correlated. Therefore, he relies only on the prior. This leads to more herding.

Notice that, as long as the probability of being pivotal is not too low, the cut-off equilibrium exists. If this probability is very low, then, unanimity occurs. The upper bound comes from this feature. Indeed, if the ability required to vote for A is too high, if only the extremely able vote for A, the probability of being pivotal decreases sharply as well as the probability of A being elected. Therefore, even the extremely able directors with a signal A would choose B, leading to unanimity for the candidate favored by the prior and making the cut-off equilibrium unsustainable. This might also occur if q is very high (leading to a high t^*).

If the concern to vote for the winner (G) is very high, this leads to unanimity for the candidate who is favored by the prior.

So, if the election is extremely biased towards one candidate (for whatever reasons) or if the directors care too much about voting for the winner, then a director who observes a signal different from the prior, even if he is extremely competent, fears to express his opinion and herds. This might be very detrimental to a firm since it limits the emergence of opposition in a board. Notice also that, as the board gets larger, the probability of being pivotal decreases. I will study this more in depth in section 8 below.

This analysis is made in the case in which all directors are independent from one another. But this is seldom the case. In boards, there is evidence of some links between members. Those ties can affect the vote as well.

5 Introducing the network effect

It is possible to expect that directors have ties between one another and that those ties do not come from the firm itself. Therefore, independent directors can still have ties with the other board members. I will loosely call this interdependence "network". The mere fact of sitting on the same board creates interconnection. This can create group dynamics and desire to conform (see on this Malenko (2010)), leading to herding. Herding is a well-studied phenomenon (see in particular Banerjee (1992) and Scharfstein and Stein (1990)). Groups of peers or networks could have an influence in how the board behaves beyond herd behavior. The literature on "old boys club" informs us that these ties indeed influence decisions such as hiring, colluding or forming groups (see Balan and Dix (2009), Byrne (1971),Rivera (2012)). In this section, I study how networks or clubs could affect the results of the election process.

To study networks, I consider that, out of the three board members who are not candidates, two are from the same network N. I do not consider that any of the two candidates is part of the network for the moment.

To understand how networks might enter in the framework, we need to go back to w_i and its interpretation. The state of the world represents who the expert is more inclined to see as the best candidate, which candidate defends, in the director's field of interest, the strategy that the director would favor. The aggregation of all states of the world represents the overall strategy advocated by each candidate. To characterize the network, I assume that experts who attended the same higher education institution, come from the same family, belong to the same groups in some other way are more likely to have the same state of the world w. This means that, with some probability, they share the same interests and value the same strategy in that field. This assumption can be justified by different things:

- They received the same education so might give a similar weigh to similar aspects;
- they had similar careers;
- they have converging interests (work in the same field, hope for the same strategy for the firm).

In my model, directors from the same network will share the same state of the world with some probability λ. The parameter $\lambda \in [0;1]$ is common knowledge. It is drawn before the w_is. $\lambda \equiv P[w_i = w_N]$ $\forall\ i \in \{N\}$ where N is a specific network. With probability λ, a common w is drawn for the two members of the network, and with probability $1-\lambda$, there are two separate draws as in the benchmark case. Then talent t and signal s remain personal and private information. The third member draws his own w.

Following the assumption that the board is optimally composed in the benchmark case, when there is a network, with probability λ, some information is lost. The candidates are evaluated in one less dimension. This is important when studying the output for the firm's owners.

Introducing a subgroup of two out of three non candidate voters creates heterogeneity among the directors. I need to study separately the directors who are part of the network and the one who is not.

Some further notations are needed. Subscript x will denote that the variable is that of the director who is not part of the network, n will refer to one of the directors in the network. Since there is symmetry between the two directors in the network, I will not use n, i and n, j. Finally, the capital letters X refers to a situation in which each director draws his own w and N to the situation in which the directors from the network share a common w.

5.1 The director out of the network

The "outside" director's private information on his w_i does not inform him on the others' w. However, he knows that the other two have the same w with some probability λ. Therefore the probabilities of A or B being elected are altered as well as the probability of being pivotal.

The indifferent director who is not in the network faces the following problem :

Lemma 4 *The indifference equation for a director who is not in the network simplifies to:*

$$v_x^*(q,s,t) = \frac{1}{2} + \frac{G}{2(1-G)} \frac{P_x[B \cap npiv] - P_x[A \cap npiv]}{P_x[Piv]} \tag{5}$$

where :

$$P_x[B \cap npiv] = \lambda P[B \cap npiv|N] + (1-\lambda)P[B \cap npiv|X] \equiv \lambda B_N(t_n^*, t_n^*) + (1-\lambda)B(t_n^*, t_n^*)$$

$$P_x[A \cap npiv] = \lambda P[A \cap npiv|N] + (1-\lambda)P[A \cap npiv|X] \equiv \lambda A_N(t_n^*, t_n^*) + (1-\lambda)A(t_n^*, t_n^*)$$

$$P_x[Piv] = \lambda P[Piv|N] + (1-\lambda)P[Piv|X] \equiv \lambda I_N(t_n^*, t_n^*) + (1-\lambda)I(t_n^*, t_n^*)$$

Compared to the benchmark case, a director who is not part of the network observes a different probability of being pivotal and assesses differently the probability that B is elected. This, in turn, changes his vote. The network affects all the board members, including the director who is not part of it.

5.2 A director in the network

A director who is part of the network can get information on his own state of the world from the other member's vote. Indeed, with some probability, they share the same w. Therefore, there is information to gain from the other's vote.

Lemma 5 *The indifference equation for a director who is in the network simplifies to:*

$$(1-\lambda)v_n^*(q,s,t) + \lambda V_n^*(q,s,t) = \frac{1}{2} + \frac{G}{2(1-G)} \frac{P[B \cap npiv] - P[A \cap npiv]}{P[piv]} \tag{6}$$

Let $P[B \cap npiv] \equiv B(t_n^*, t_x^*)$, $P[A \cap npiv] \equiv A(t_n^*, t_x^*)$ and $P[piv] \equiv I(t_n^*, t_x^*)$ Compared to the benchmark case, the director who is part of the network has access to more information on his w. This alters his voting strategy.

5.3 Cut-off equilibrium in the network case

Solving the equilibrium here is slightly more involved than in the benchmark case since the directors are not symmetric anymore. Notice however that in the case in which $\lambda = 0$, we are back in the benchmark case and the only solution is that $t_x^* = t_n^* = t_0^*$ (where t_x^* is the cut-off for the director who is not part of the network and t_n^* that of the directors who are part of the network.

Lemma 6 *In equilibrium $t_n^* \leq t_x^*$, with equality when $\lambda = 0$ or when unanimity arises.*

Proposition 3 *In the case of a network, there exists one cut-off equilibrium where $s_n^* = s_n^* = A$, $t_n^*(q,G)$, $t_n^* \leq t_x^* \leq t_0^*$. t_x^*, t_n^* and t_x^* are bounded away from 1. There exists another equilibrium in which every director votes for B when G is high enough.*

We can divide the intuition into two parts.

The director who is not part of the network is less likely to be pivotal since the other two have correlated states of the world. Therefore, the bias towards the winner has a stronger role. If the two other directors had the same strategy as a benchmark director (the same cut-off), this would lead the director out of the network to vote for the candidate favored by the prior more often than in the benchmark case (and have a higher cut-off point). But this is not the case because directors from the network have a lower cut-off than in the benchmark case. Therefore, B is still more likely to be elected than A, but less so than in the benchmark case. The director who is out of the network and who is more biased towards the winner tends to vote more often for A than in the benchmark case (but less often than an efficient director). Notice that when $G = 0$, the director is efficient and the network has no effect on his vote.

When a director is part of the network, the cut-off decreases as well, even when there is no bias towards the winner. Indeed, when $G = 0$, the cut-off is lower than q. A director i who is part of a network votes for A more often when he has a signal A than an efficient director. This reflects the loss of efficiency coming from the lost information. Indeed, since information is now correlated, a director in the network with a signal A can retrieve information on his network co-member's vote. If he believes he is pivotal, this means that out of the two other directors, one voted for A. It is more likely that the director who voted for A is the one from the network since the cut-off point is lower. If that director voted for A, it means that he had a signal A and was sufficiently able to trust it. Therefore, if the other director from the network has a signal A and if states of the world are correlated ($\lambda > 0$), he can give it higher credit. The updated probability that his $w = A$ is higher with the same t.

This result shows that, when there is a subgroup in a committee, this group gains power to vote for its best candidate. Indeed, the members of the network vote for A only if $s = A$, that is, only if they believe A to be their best candidate. But if that is so, they trust their signal more than a benchmark director. Moreover, in a context in which there is a network, the director who is not part of that network will vote for A more often than in the benchmark case, leading to a higher probability that A is elected, when he is the best candidate of the network members. Notice that this voting behavior from the director who is not part of the network arises only to conform to the others, because it does not happen when $G = 0$.

5.4 Unanimity in the network case

By increasing the probability that A is elected, introducing a network limits the cases in which there is unanimity if no candidate is part of the network.

Proposition 4 *The $\bar{G}_N$ that leads to a unanimous vote for B is higher than in the benchmark case ($\bar{G}_N > \bar{G}_0$). This means that unanimity arises for a smaller set of parameters when there is a network and no candidate is part of that network.*

This feature comes from the extra power gained by the members of the network: they express their opinion more often and lead the director who is not part of the network to vote for A more often, hoping to vote like the members of the network. This result comes in part from the behavior of the member who is not part of the network. This director has a lower probability of being pivotal than in the benchmark case. Therefore he cares for voting for the winner more. This could lead to a tendency to vote for the candidate favored by the prior. But, on the other hand, the directors who are from the network vote for A more often than in the benchmark case. There is a less clear cut as to which candidate is going to be elected, reducing the expected gain of voting like the prior.

6 One candidate is part of the network

In the previous section, I have studied the bias caused by the existence of a network among the voting directors, assuming neither candidate is part of the network. Another important question is to understand what happens when one candidate is part of the network (and not the other). This is of interest to us because it is close to the idea that network members can favor their peer, a behavior which is often associated with networks in the public opinion. We expect to see it at work at the time of the election of the CEO.

In this framework, when a candidate is part of the network, it means that with probability λ, all members of the network will have the w of the candidate (more information is lost). That is, if the candidate in the network is A, all the network members will have $w = A$ with probability λ and this is common knowledge since the w of the candidates are common knowledge.

The case of B candidate of the network is the most obvious since B is already favored by the prior. Compared to the previous case (no candidate from the network), B is more likely to win and unanimity arises for a larger set of parameters.

Proposition 5 *If B is part of the network, $t^*_{n,B} > t^*_{x,B} > t^*_0 > q$ and $\bar{G}_{N,B} < \bar{G}_0$.*

On the other hand, when A is candidate, the prior goes against the network candidate. The question is therefore whether the network can be stronger than the prior, i.e., will all directors bend their votes against the prior.

Proposition 6 *When A is the candidate of the network, there is a unique equilibrium which varies, depending on λ and G: $s^*_n = s^*_x = A$ and $t^*_n < t^*_x < t^*_0$ (for lower values of λ). As λ increases, the equilibrium shifts towards one with $s^*_n = B$ and $s^*_x = B$ and $t^*_x < t^*_0$. Recall that in this equilibrium, a director from the network votes for A if he has signal A or if he has signal B and a $t < t^*_{n,A}$. For G or λ high enough, there is unanimity for A*

This shows that when the ties of the network are strong (high λ) there exists an equilibrium where every director votes for A, going against the prior. This is very interesting because it shows that the network, in a context of directors concerned about voting for the winner, can bias the votes not only towards more herding around the "natural" candidate but even more around the challenger. This also shows that network can play an important part in being elected Chairman and can, in some cases, supplement ability. That could be very detrimental to stockholders.

7 Optimum comparisons

It is interesting to study how the different cases affect the "welfare" of the stockholders. As in Levy (2007b), a "natural" criterion for efficiency of the board is the probability that the decision is correct on all dimensions. Efficiency can be measured as the probability that every director votes correctly, votes as his w_i suggested. In other words, I study the probability that $m_i = w_i$ for every i.

When all directors are symetric, it suffices to compute this probability for one director. Here, unlike in Levy, all directors are not symmetric ex ante in all cases, so I need to study each case separately. Let $W(t_i, t_j, t_k) \equiv ((1-q)m_a(t_i) + q(1-m_b(t_i)))((1-q)m_a(t_j) + q(1-m_b(t_j)))((1-q)m_a(t_k) + q(1-m_b(t_k)))$ where m_a, the probability to vote for A when $w = A$, is $m_a(t) = 1 - t^2$ and m_b, the probability to vote for A when $w = B$, is $m_b(t) = (1-t)^2$.When $W(.)$ is minimized, the probability of error is minimized, welfare is maximized.

7.1 From efficient to benchmark case - effect of introducing the bias to vote for the winner

In the efficient case, the directors maximize the value of the firm; therefore, there should not be a gain from deviating.

Proposition 7 *$W(t^*_{eff}) > W(t^*_0)$ where $W(t^*_{eff})$ is the welfare associated with the cut-off strategy adopted from efficient directors (cut-off point t^*_{eff}) and $W(t^*_0)$ is the welfare associated with the cut-off strategy adopted by directors in the benchmark case (cut-off point t^*_0)*

This fact is not surprising and it shows that, when deviating from the goal of value-maximizing, the directors decrease the welfare of the stockholders. Again, by definition of efficient, this is an expected result.

7.2 No preference for the winner, with and without network - effect of introducing network

To study the welfare in the network case, I consider that the correct w_i of each director is the one drawn in the absence of correlation, the one drawn with probability $1 - \lambda$. This comes from my definition of w and the assumption that, in the absence of network, the aggregation of the three ws reflects perfectly all available information on the candidates. Therefore, what enhances the welfare of the firm's owners is that each director votes like this w, allowing for the best information aggregation. When the network is introduced, with probability λ, some information is lost since only two ws then become observable or retrievable instead of three. This assumption leads to consider that introducing a network leads to a loss of welfare (by assumption since I consider that aggregating the three ws leads to a perfect information on the candidates).

Proposition 8 *$W(t^*_{eff}) > W(t^*_{N,eff})$ where $W(t^*_{eff})$ is the welfare associated with the cut-off strategy adopted from efficient directors (cut-off point t^*_{eff}) and $W(t^*_{N,eff})$ is the welfare associated with the cut-off strategy adopted by directors in a board in which there is network but no bias to vote for the winner (cut-off point t^*_0).*

This distortion from the efficient case by introducing the network comes from the assumption that the board composition is optimal. Of course, when there is network and a bias to vote for the winner, there is also a loss of welfare compared to the efficient case.

What is of interest is the comparison between the benchmark and the network case.

7.3 From benchmark to network - no candidate is part of the network

Proposition 9 *When G is greater than some value $\tilde{G}(q)$, $W(t_N^*) > W(t_0^*)$ where $W(t_N^*)$ is the welfare associated with the cut-off strategy adopted from directors in a board where there is a network., In particular, $W(t_N^*) > W(uB)$ where $W(uB)$ is the welfare associated with a unanimous vote for B*

This proposition comes from the intuition I developed earlier. Let us consider only the case in which $G > \tilde{G}(q)$, that is when there is a substantial deviation from the efficient strategy in the benchmark case.

When there is a network in a board, the directors from the network "make" the election. They have more power than a director in the benchmark case in the sense that it is more likely that, by voting for their "best" candidate they also vote for the winner: they are more likely to be pivotal and there is a possibility that, when they are not pivotal, the pivotal voter shares the same best candidate and votes accordingly. In that set up, the directors who are part of the network have a "best" candidate determined by the prior. Of course there is a loss of efficiency when there is network since some information is lost. But the deviation from the efficiency is smaller (for G high enough, that is, when the deviation in the benchmark case is important). This result comes from the power of the network and its ability to trust its signal more. This in turn leads the director who is out of the network (and who therefore has less power than in the benchmark case) to behave more efficiently because B is less likely to be elected. Therefore, the expected gain from herding with the prior is dampened and leads this director to follow her signal more often as well. As we have seen, unanimity arises faster in the benchmark case than in the case in which there is a network inside the board, but no candidate is part of the network. Unanimity is detrimental for the firm because even when q is high, there is always a chance $(1-q)^2$ that A is the best candidate for the firm. Unanimity prevents the election of A in any case (even with very able directors).

7.4 B is a candidate in the network

Proposition 10 $W(t^*_{N,B}) < W(t^*_0)$ *where* $W(t^*_{N,B})$ *is the welfare associated with the voting strategy of a board with a network and B part of that network*

The intuition still comes from the power the network has. The network decides who is going to be elected (broadly speaking). Therefore, when no candidate is part of the network, this is good for the stockholders because the network acts close to what the states of the world dictates. But as soon as one candidate is part of the network, their interest is to elect that candidate (with probability λ he is their best candidate). Information loss is more important since two dimensions of evaluation disappear with probability λ. This becomes detrimental for the firm because B is the best candidate with probability q^2. But when there is a network and when B is part of that network, he becomes the candidate perceived as best with probability $(1-\lambda)q^2 + \lambda$, which is higher. The interests of the stockholders and that of the directors inside the network diverge. The extra power that the directors gain from the network becomes detrimental.

7.5 A is a candidate in the network

Proposition 11 $W(t^*_{N,A}) < W(t^*_0)$ *where* $W(t^*_{N,A})$ *is the welfare associated with the voting strategy of a board with a network and A part of that network*

The analysis is the same as above except now the interest diverges even further. For the firm A is the best candidate with probability $(1-q)^2$. But when there is a network and when B is part of that network, he becomes the candidate perceived as best with probability $(1-\lambda)((1-q)^2) + \lambda$. The difference is even greater than in the case where B is the candidate from the network.

7.6 Summary of optima comparisons

There are situations in which the network can be good for the stockholders. This is the case when directors are not efficient and worry about electing the winner. To that respect, the network can give them more power to elect who they think is best rather than just trying to conform to the others and herd around the candidate favored by the prior. However, this power can prove detrimental if the interests of the directors do not align with that of the stockholders and more specifically if one candidate is part of the network. In that case, the existence of a network inside the board becomes detrimental. The question that now arises is whether it is credible to think that, in a board where there is a network among directors, no candidate is going to come from that network. I have assumed that candidates are exogenous and that G is exogenous as well. It could be argued that there is a first stage where board members decide to run for the job of CEO. In that setting, it is possible to think that at least one candidate will be from the network and in that sense, having a network inside a board would always be detrimental for the firm. It is not the scope of this paper to study this, but it would certainly be of interest.

8 Extensions

8.1 Increasing the number of board members

Increasing the number of board members distorts the votes even in the benchmark case when $G \neq 0$. We can take a very simple example of that. Imagine a board in which there is no election but rather they randomly draw which director chooses the result of the election. In a case of a three-member board, the probability of being pivotal is $\frac{1}{3}$, in a case of a five-member board, the probability falls to $\frac{1}{5}$. In our case, the probability of being pivotal is less obvious to compute but the idea is similar. Therefore, if the number of people on a board increases, the directors will put more weight on voting for the winner. This is equivalent to increasing G. It appears therefore that very large boards might be less efficient when choosing their CEO/ Chairman.

Proposition 12 *When the number of board member increases, directors tend to vote more for B. There exists a $\bar{J}(q)$ for which, directors vote for B for any signal and any ability when $G > 0$*

The proposition comes from the fact that, as the number of board member increases, the probability of being pivotal decreases. This limits the responsibility of each director in the final decision but it makes each more eager to vote for the winner, because comparatively this is how he can best increase his expected payoff.

8.2 Endogenizing G

In the model as I present it, G is exogenous and the same for all board members. One could argue that the premium for voting for the winner depends on the number of people who voted for him or whether the director who voted for him is from the same network.

If the election is close, the winner will value each vote more. If that is so, G should vary with the number of votes.

Remark 7 *If G is a function of the number of final votes, the results do not change substantially, they just correspond to a rescaling of G.*

This result is true in the particular set up of the model because, in this model, directors worry about G only if they are not pivotal. Therefore, they will get $G(3votes)$ or nothing at all. If I consider that $G(2votes) > G(3votes)$, endogenizing G comes back to an exogenous G but lower than in the general model. However, if they were more than 3 directors whose vote counted, this particular result could be altered.

9 Concluding remarks

In this paper, I have shown that, if we assume that directors are concerned not only about the value of the firm but also about the favors they could get from the Chairman, they will not vote efficiently. This is likely the case since indeed the Chairman has power to provide favors or retaliate against board members. This effect combined with networks inside the board affects every director's vote. The results show that having a network inside a board is beneficial for stockholders as long as members of that network are not candidates to become CEO. In that case, the existence of a network gives power to its members which balances that of the future CEO. It therefore limits the incentive of voting for the future winner and reinforces the incentive to vote for the best candidate. This result contradicts common intuition that networks are detrimental in general. Here, I show that it can provide power to directors who are part of this network and decrease the power of the CEO over every member of the board, including directors who are not part of the network. This, in turn, allows them to vote efficiently. In this paper, I study only the CEO's election process. However, it is likely that the extra power directors have when part of a network could affect other decisions on a board (strategy, compensation, dividends). However, as the results show, if one member of the network is candidate to become CEO, the existence of a network becomes detrimental. In the paper, I assume that candidacy is exogenous but it is very likely not the case. If so, one could suppose that in a board with a powerful network, at least one candidate will be from that network.

10 Appendix

10.1 Preliminaries

Lemma 8 $\partial\beta(t,t) > 0$*on the range of G that makes the equlibrium sustainable (i.e. for* $0 \leq G \leq \bar{G}$*)*

Proof of Lemma 8.

Let $\beta(t,t) \equiv v(q,s,t) - \frac{G}{2(1-G)}r(t,t)$ where $r(t,t) \equiv \frac{B(t,t)-A(t,t)}{I(t,t)}$. We have $\frac{\partial v(q,s,t)}{\partial t} > 0$ and $\frac{\partial r(t,t)}{\partial t} > 0$. Therefore it must be that at $G = 0$, $\frac{\partial \beta(t,t)}{\partial t} > 0$ and that at $G = 1$,$\frac{\partial \beta(t,t)}{\partial t} < 0$. Besides, $\frac{\partial \beta(t,t)}{\partial G} < 0$. By continuity, there exists a $\tilde{G}$ such that $\frac{\partial \beta(t,t)}{\partial t} = 0$.
The claim is that $\tilde{G} > \bar{G}$, leading to $\frac{\partial \beta(t,t)}{\partial t} > 0$ for $0 \leq G \leq \bar{G}$.
Suppose this is not the case and $\tilde{G} < \bar{G}$ In equilibrium (for $G < \bar{G}$), $v(q,s,t^*) = 1/2 + \frac{G}{2(1-G))}r(t^*,t^*)$, therefore, $\frac{\partial v(q,s,t^*)}{\partial t^*} = \frac{G}{2(1-G)}\frac{\partial r(t^*,t^*)}{\partial t^*}$, for all G, including a G such that $\tilde{G} < G < \bar{G}$. Therefore it must be that $\frac{G}{2(1-G)}\frac{\partial r(t^*,t^*)}{\partial t^*} - \frac{\tilde{G}+\epsilon}{2(1-\tilde{G}+\epsilon)}\frac{\partial r(t^*,t^*)}{\partial t^*} < 0$ (with $\epsilon > 0$) which leads to $\tilde{G} > G > \bar{G}$, which contradicts the supposition. Therefore, it must be that $\tilde{G} > \bar{G}$. ■

Proof of Lemma 6.

Substracting (5) from (6), we get:

$$v(q,s^*,t_n^*) - v(q,s^*,t_0^*) + \lambda(V(q,s^*,t_n^*,t_x^*) - v(q,s^*,t-n^*)) =$$
$$\frac{G}{2(1-G)}(\frac{B(t_n^*,t_x^*) - A(t_n^*,t_x^*)}{I(t_n^*,t_x^*)} - \frac{B(t_n^*,t_n^*) - A(t_n^*,t_n^*)}{I(t_n^*,t_n^*) + \lambda(I(t_n^*,t_n^*) - I_X(t_n^*,t_n^*))}$$

Suppose $t_n^* > t_x^*$, then :

$$\lambda((V(q,s^*,t_n^*,t_x^*) - v(q,s^*,t-n^*))+$$
$$(B(t_n^*,t_x^*) - A(t_n^*,t_x^*))\frac{G}{2(1-G)}\frac{(I_X(t_n^*,t_n^*) - I(t_n^*,t_n^*))}{I(t_n^*,t_x^*) * (I(t_n^*,t_n^*) + \lambda(I_X(t_n^*,t_n^*) - I(t_n^*,t_n^*)))} <$$
$$\frac{G}{2(1-G)}((B(t_n^*,t_x^*) - A(t_n^*,t_x^*))I(t_n^*,t_n^*) - (B(t_n^*,t_n^*) - A(t_n^*,t_n^*))I(t_n^*,t_x^*)$$

The right hand side is always positive but the left hand side is positive if and only if $t_x^* > t_n^*$. Which contradicts our supposition. Therefore, it must be that $t_n^* \geq t_x^*$ with equality when $\lambda = 0$ ■

10.2 The benchmark case

Proof of proposition 1. Let $v_i(q,t,s) \equiv Pr(w_i = a|q,s_i,t_i)$. In this case, an indifferent director between voting for A and voting for B will face (I drop the subscripts) :

$$v(q,s,t)(u(A|w=A))+(1-v(q,s,t)(u(A|w=B)) = v(q,s,t)(u(B|w=A))+(1-v(q,s,t))(u(B|w=B)) \quad (7)$$

The left hand side is the utility from voting for A and the right hand side is the utility from voting for B. I have $u(A|w = A) = u(B|w = B) = 1$ and $u(A|w = B) = u(B|w = A) = 0$. Rearranging the equation above, we get:

$$v(q,s,t) = 1/2$$

If $s = B$, the left hand side is always smaller than $1/2$ (for all $q > 0.5$). This means that a director with a signal B always votes for B. The equilibrium has to admit $s^* = A$. If $s^* = A$, the equation holds for $t_{eff}^* = q$. If $t > t_{eff}^* = q$, $v(q,s,t)$ is greater than $1/2$ and the director votes for A. ■

Proof of Lemma 1. If G is small enough, some types vote for A and some for B. Therefore, there must exist a type (s,t) who is indifferent between the two votes. For this (s,t), the following must hold:

$$P[piv](V(q,s,t)((1-G)) + (1-P[piv])P[A|npiv]G = \\ P[piv]((1-V(q,s,t))(1-G)) + (1-P[piv])P[B|npiv]G \tag{8}$$

where $P[piv]$ is the probability of being pivotal, $P[D|npiv]$ is the probability of D being elected knowing that the director is not pivotal $V(q,s,t) = \frac{P[piv|w=a]v(q,s,t)}{P[piv|w=a]v(q,s,t)+P[piv|w=b](1-v(q,s,t))}$. Notice that in the case where there is no correlation between the w of the directors $V(q,s,t) = v(q,s,t)$ or, rearranging:

$$v(q,s,t) = \frac{1}{2} + \frac{G}{2((1-G))}\frac{P[B\cap npiv] - P[A\cap npiv]}{P[piv]} \tag{9}$$

The right hand side is fixed for (s,t) since it depends only on the other members of the board, their types and their strategy. The other members cannot condition their strategies on s,t since they do not know them. The left hand side changes with (s,t) and $v(q,A,t)$ is strictly increasing in t and $v(q,b,t)$ is strictly decreasing in t. They are equal for $t = \frac{1}{2}$, so there can be only one (s^*,t^*) that satisfies the equation. ■

Proof of Lemma 2. Conjecture an equilibrium with a cut-off point t^* and $s^* = A$ such that a director votes for A if and only if $s = A$ and $v > v^*$. Denote m_w the probability that a director with w votes for A, we get : $m_A = \int_{t^*}^{1} 2tdt = 1 - t^{*2}$ and $m_b = \int_{t^*}^{1} 2(1-t)dt = (1-t^*)^2$. Now, we can write:

$$\frac{(1-P[Piv])P[A|nonpiv]}{1-P[Piv]} = P[A\cap nonpiv] \text{ and } \frac{(1-P[Piv])P[B|nonpiv]}{1-P[Piv]} = P[B\cap nonpiv]$$

$$<=> (1-P[Piv])P[A|nonpiv] - (1-P[Piv])P[B|nonpiv] = 1 + 4q(-1+t^*)t - 2t^{*2} < 0$$

$$\forall \quad 0.5 \le t^* \le 1 \text{ and } 0.5 < q \le 1$$

■

Proof of Lemma 3. The cut-off strategy implies that a director votes for A is $v(q,s,t) > v^*(q,s,t)$.

CASE 1 : $s^* = B$. First, conjecture a cut-off equilibrium in which $s^* = B$. If that is true, every director with $s = A$ votes for A (for all t) since $v(q,A,t) > v(q,B,t^*)\forall t$ and some directors with a signal $s = B$ vote for A (for values of t lower than some t^*) since $v(q,B,t) > v(q,B,t^*)$ if $t < t^*$. In turn, the two following inequalities are necessary conditions for the existence of a cut-off equilibrium in which $s^* = B$:

$$v(q,A,t) > \frac{1}{2} + \frac{G}{2(1-G)}\frac{P[B \cap npiv] - P[A \cap npiv]}{P[piv]} \quad \forall t \text{ and } 0 \leq G < \bar{G}_0$$
$$v(q,B,t) > \frac{1}{2} + \frac{G}{2(1-G)}\frac{P[B \cap npiv] - P[A \cap npiv]}{P[piv]} \text{ for some } t$$

where $\bar{G}_0$ is the upper bound on G above which unanimity always occur. This first inequality does not hold for all t. (For instance, if $G = 0$ it does not hold for $t = 0.5$). A cut-off equilibrium cannot admit $s^* = B$ *CASE 2 :* $s^* = A$. Conjecture $s^* = A$, this means that a director that observes $s = B$ votes always for B since $v(q,B,t) < v(q,A,t^*)$ for all t. A director who observes $s = A$ votes for A when since $v(q,A,t) > v(q,A,t^*)$, $t > t^*$.Therefore, the two necessary conditions are:

$$v(q,A,t) > \frac{1}{2} + \frac{G}{2(1-G)}\frac{P[B \cap npiv] - P[A \cap npiv]}{P[piv]} \text{ for some } t$$
$$v(q,B,t) < \frac{1}{2} + \frac{G}{2(1-G)}\frac{P[B \cap npiv] - P[A \cap npiv]}{P[piv]} \quad \forall t \text{ and } 0 \leq G < \bar{G}_0$$

There exists at least a $t(G)$ such that the first inequality holds. For instance, for $G = 0$, we are back in the "efficient" case and the inequality holds for every t greater than q. The second inequality holds. The right hand side is greater than $\frac{1}{2}$ since it is increasing in G because of lemma 2.The left hand side is always lower than 1/2 for $q > 1/2$.

Therefore, it has to be that $s^* = A$ in equilibrium. ■

Proof of proposition 2.

Following 1, the equilibrium solves:

$$v^*(q, s, t) = \frac{1}{2} + \frac{G}{2((1-G))} \frac{P^*[B \cap npiv] - P^*[A \cap npiv]}{P^*[piv]} \tag{10}$$

which is the equation when all directors use the optimal strategy and the probabilities are calculated using the equilibrium cut-off point.

Step 1:

The existence of a cut-off equilibrium $(s^* = A, t^*)$ follows from lemmas 1 and 3.

Step2:

For the fixed point equation to hold, we need the right hand side to be less than 1 since $v(q, s, t)$ is at most 1. However, the right hand side is not bounded. It is a monotone (increasing) function of t for $0.5 \leq t \leq 1$ [1] and $lim_{t->1} rhs = \infty$. Therefore there must exist a $\bar{t} < 1$ such that for $t > \bar{t}$ the right hand side is greater than 1.It must be that $t_0^* < \bar{t}$.

Step 3 :

For the fixed point equation to hold, we need the right hand side to be less than 1 since $v(q, s, t)$ is at most 1. However, the right hand side is not bounded. It is a monotone (increasing) function of G [2] and $lim_{G->1} rhs = \infty$. There exists a $\bar{G}_0$ such that, if $G > \bar{G}_0$, $rhs > 1$. In this case, no director votes for A and a cut-off equilibrium is not sustainable.

■

[1] $\frac{\partial rhs}{\partial t} = \frac{G}{2(1-G)} \frac{\frac{\partial (P[B \cap npiv] - P[A \cap npiv])}{\partial t} P[Piv] - \frac{\partial (P[Piv])}{\partial t} (P[B \cap npiv] - P[A \cap npiv])}{P[piv]^2}$, we have: $\frac{\partial (P[Piv])}{\partial t} < 0$,$(P[B \cap npiv] - P[A \cap npiv]) > 0$ and $\frac{\partial (P[B \cap npiv] - P[A \cap npiv])}{\partial t} > 0$ so $\frac{\partial rhs}{\partial t} > 0$

[2] $\frac{\partial rhs}{\partial G} = \frac{1}{2(1-G)^2} \frac{(P[B \cap npiv] - P[A \cap npiv])}{P[Piv]} > 0$

10.3 The network case

Proof of Lemma 4. The full length indifference equation is:

$$(1-\lambda)(P[piv|X]V_x(q,s,t,X)(1-G)+(1-P[piv|X])P[A|npiv,X]G)$$
$$+\lambda(P[piv|N]V_x(q,s,t,N)(1-G)+(1-P[piv|N])P[A|npiv,N]G)=$$
$$(1-\lambda)(P[piv|X](1-V_x(q,s,t,X))(1-G)+(1-P[piv|X])P[B|npiv,X]G)$$
$$+\lambda(P[piv|N](1-V_x(q,s,t,N))(1-G)+(1-P[piv|N])P[B|npiv,N]G)=$$

where:

$$V_x(q,s,t,Z)\equiv\frac{v_x(q,s,t)P[Piv|Z,w=a]}{v_x(q,s,t)P[Piv|Z,w=a]+(1-v_x(q,s,t))P[Piv|Z,w=b]}$$

with $Z=\{X,N\}$.

Since the director who is not part of the network cannot learn anything on the other directors' w from his own, he has $V(q,t,s,\lambda)=v(q,s,t)$. We can simplify the equation to get:

$$v_x(q,s,t)=\frac{1}{2}+\frac{G}{2(1-G)}\frac{(1-\lambda)(P[B\cap npiv|X]-P[A\cap npiv|X])+\lambda(P[B\cap npiv|N]-P[A\cap npiv|N])}{(1-\lambda)P[piv|X]+\lambda P[piv|N]}$$

Denote the probability that B is elected when the director who is not part of the network is not pivotal $P_x[B\cap npiv]=\lambda P[B\cap npiv|N]+(1-\lambda)P[B\cap npiv|X]$. Likewise $P_x[A\cap npiv]=\lambda P[A\cap npiv|N]+(1-\lambda)P[A\cap npiv|X]$ and $P_x[Piv]=\lambda P[Piv|N]+(1-\lambda)P[Piv|X]$

We get (5):

$$v_x(q,s,t)=\frac{1}{2}+\frac{G}{2(1-G)}\frac{P_x[B\cap npiv]-P_x[A\cap npiv]}{P_x[Piv]}$$

■

Proof of Lemma 5. The full length indifference equation is:

$$(1-\lambda)(P[piv|X]V(q,s,t,X)(1-G)+(1-P[piv|X])P[A|npiv,X]G)$$
$$+\lambda(P[piv|N]V(q,s,t,N)(1-G)+(1-P[piv|N])P[A|npiv,N]G)=$$
$$(1-\lambda)(P[piv|X](1-V(q,s,t,X))(1-G)+(1-P[piv|X])P[B|npiv,X]G)$$
$$+\lambda(P[piv|N](1-V(q,s,t,N))(1-G)+(1-P[piv|N])P[B|npiv,N]G)=$$

The difference with the director who is not part of the network is that $V(q,s,t,N) \neq v(q,s,t)$ since his w is correlated with that of the other member of the network. Therefore he can update his information on his w given his beliefs on the other director's vote. On the other hand, $P[piv|X] = P[piv|N]$ and $P[D|npiv,X] = P[D|npiv,N]$. Indeed, the two remaining directors are not part of the same network (one is in the network and one is not), therefore, their w_i are not correlated. This can be rewritten as (6):

$$(1-\lambda)v^*(q,s,t)+\lambda V(q,s,t)=\frac{1}{2}+\frac{G}{2((1-G))}\frac{P^*[B\cap npiv]-P^*[A\cap npiv]}{P^*[piv]} \tag{11}$$

■

Proof of proposition 3.

Step1: Existence and uniqueness

For existence, we can follow lemma 1. The indifference equations are now:

$$v_x(q,s,t)=\frac{1}{2}+\frac{G}{2(1-G)}\frac{P_x[B\cap npiv]-P_x[A\cap npiv]}{P_x[Piv]} \tag{12}$$

$$(1-\lambda)v^*(q,s,t)+\lambda V(q,s,t)=\frac{1}{2}+\frac{G}{2(u(A|A)-u(A|B))}\frac{P^*[B\cap npiv]-P^*[A\cap npiv]}{P^*[piv]} \tag{13}$$

The rest of the proof of lemma 1 can be applied.

Step 2:$s_x^* = s_n^* = A$

Just as in the benchmark case, an equilibrium with $s^* = B$ cannot be sustained. If $s_x^* = s_n^* = B$, then we would need:

$$v_x(q,A,t) > \frac{1}{2} + \frac{G}{2(1-G)}\frac{P_x[B\cap npiv] - P_x[A\cap npiv]}{P[piv]} \quad \forall t,\lambda \text{ and } 0\leq G<\bar{G}_0$$
$$(1-\lambda)v_n(q,A,t)+\lambda V_n(q,A,t) > \frac{1}{2} + \frac{G}{2(1-G)}\frac{P[B\cap npiv] - P[A\cap npiv]}{P[piv]} \quad \forall t,\lambda \text{ and } 0\leq G<\bar{G}_0$$

We know that neither equation holds (for $\lambda = 0$, for instance). Therefore, the equilibrium cannot admit $s_n^* = s_x^* = B$.

The equilibrium has to admit $s^* = A$ for the directors part of the network or not. *Step 3*: Determining the bound

Just as in the benchmark case, for the equilibrium to hold, we need both right hand sides to be less than 1 and both sides tend to infinity as t_n^* goes to 1. Therefore, it must be that there exists a $\bar{t}_{n,x}$ that makes the right hand side of equation (12) equal to 1 and $\bar{t}_{n,n}$ that makes the right hand side of (13) equal to 1. Notice that the two right hand side depend only on t_n^* since t_x is a function of t_n. The lowest of $\bar{t}_{n,x}$ and $\bar{t}_{n,n}$ is the upper bound $\bar{t}_n$ on t_n^*. In turn that gives an upper bound to t_x where $\bar{t}_x^* = f(\bar{t}_n^*)$

Step 4 : deriving the cut-off points

Let us substract (10) and (5), we obtain:

$$v(t_0^*)-v(t_x^*) = \frac{G}{2(1-G)}(\frac{B(t_0^*,t_0^*)-A(t_0^*,t_0^*)}{I(t_0^*,t_0^*} - \frac{B(t_n^*,t_n^*)-A(t_n^*,t_n^*)}{I(t_n^*,t_n^*)} - \lambda\frac{I(t_n^*,t_n^*)-I_N(t_n^*,t_n^*)}{I(t_n^*,t_n^*)+\lambda(I_N(t_n^*,t_n^*)-I(t_n^*,t_n^*))} \tag{14}$$

We have $\frac{I(t_n^*,t_n^*)-I_N(t_n^*,t_n^*)}{I(t_n^*,t_n^*)+\lambda(I_N(t_n^*,t_n^*)-I(t_n^*,t_n^*))} < 0$ for all t_n , therefore (if $r(t_0,t_0) \equiv \frac{G}{2(1-G)}\frac{I(t_n^*,t_n^*)-I_N(t_n^*,t_n^*)}{I(t_n^*,t_n^*)+\lambda(I_N(t_n^*,t_n^*)-I(t_n^*,t_n^*))}$

$$v(t_0^*)-v(t_x^*) \geq r(t_0^*)-r(t_n^*)$$

$<=> v(t_0^*)-v(t_n^*) \geq r(t_0^*)-r(t_n^*)$ since $t_n^* < t_x^*$ by lemma 6 $<=> r(t_0^*)-v(t_0^*) \leq r(t_n^*,t_x^*)-v(t_n^*)$

Let $\beta(t_0^*,t_0^*) \equiv r(t_0^*,t_0^*)-v(t_0^*)$. By lemma 8 , we know that $\frac{\partial\beta(x,x)}{\partial x} > 0$ for $G<\bar{G}$. Therefore, when a cut-off equilibrium is sustainable $t_0^* > t_n^*$. But we have $v(t_0^*)-v(t_x^*) \geq r(t_0^*)-r(t_n^*)$ and $r'(t) > 0$ so $v(t_0^*)-v(t_x^*) \geq 0 => t_0 \geq t_x^*)$ with equality when $G=0$ or $\lambda = 0$ ■

Proof of proposition 4. We define $\bar{G}$ as the G for which a cut-off equilibrium is no longer sustainable. All cut-offs increase continously with G but, for all values of G $t_0^* > t_x^*$ and $t_0^* > t_n^*$. It must be that, for $\bar{G}_0$ such that $t_0^* = 1$, $t_x^* < 1$ and $t_n^* < 1$.
In turn, it must be that the $\bar{G}_X$ and $\bar{G}_N$ such that T_x^* and t_n^* are greater than 1 are greater than $\bar{G}_0$. ■

Proof of proposition 5. When B is part of the network, the indifference equation for the director who is part of the network becomes:

$$(1-\lambda)v^*(q,s,t) = \frac{1}{2} + \frac{G}{2(u(A|A) - u(A|B))}\frac{P^*[B \cap npiv] - P^*[A \cap npiv]}{P^*[piv]} \tag{15}$$

We have $\frac{\partial t^*_{n,B}}{\lambda} > 0$. In turn, we have $\frac{\partial t^*_{x,B}}{\lambda} > 0$. Both cut-off points are higher than in the benchmark case. ■

Proof of proposition 6. It is not necessary that $s^* = A$ however the cut-off equilibrium is unique (either $s^* = A$ or $s^* = B$ for each type of director) from lemma 1. I will separate between the directors from the network and the director out of the network.
Directors in the network
For such an equilibrium with $s_n^* = A$ to hold we need:

$$\begin{aligned}(1-\lambda)v(q,a,t) + \lambda &= \frac{1}{2} + \frac{G}{2(1-G)}\frac{P_n[B \cap npiv] - P_n[A \cap npiv]}{P_n[Piv]}[forsome]t \\ (1-\lambda)v(q,b,t) + \lambda &< \frac{1}{2} + \frac{G}{2(1-G)}\frac{P_n[B \cap npiv] - P_n[A \cap npiv]}{P_n[Piv]}[forall]t\end{aligned}$$

The equilibrium holds for $\lambda = 0$, so there are cases in which $s_n^* = A$ but as λ increases, the left hand side of the second equation increases and can become greater for some t than the left hand side (depending on the value of$G$). It mus be that there is a t such that both sides are equal. [3]. Since $v(q,a,t) > v(q,b,t)$ for all t and all $0.5 < q < 1$, when this is the case, it must be that $(1-\lambda)v(q,a,t) + \lambda >$

[3]The limit case is $\lambda = 1$ and $G = 0$, in which case, it does not depend on t and only a vote for A is an equilibrium

$\frac{1}{2} + \frac{G}{2(1-G)} \frac{P_x[B \cap npiv] - P_x[A \cap npiv]}{P_x[Piv]} [forall]t$. So we have the following equations:

$$(1-\lambda)v(q,a,t) + \lambda > \frac{1}{2} + \frac{G}{2(1-G)} \frac{P_n[B \cap npiv] - P_n[A \cap npiv]}{P_n[Piv]} [forall]t$$
$$(1-\lambda)v(q,b,t) + \lambda = \frac{1}{2} + \frac{G}{2(1-G)} \frac{P_n[B \cap npiv] - P_n[A \cap npiv]}{P_n[Piv]} [forsome]t$$

Those are the conditions for an equilibrium with $s_n^* = B$. Therefore, there must be a $\lambda_n \bar(G)$ such that if $\lambda < \lambda_n \bar(G)$, $s_n^* = A$ and if $\lambda > \lambda_n \bar(G)$ $s_n^* = B$.

Directors in the network

For $s_x^* = A$ to be a possible equilibrium, the following conditions must hold:

$$v(q,a,t) = \frac{1}{2} + \frac{G}{2(1-G)} \frac{P_x[B \cap npiv] - P_x[A \cap npiv]}{P_x[Piv]} [forsome]t$$
$$v(q,b,t) < \frac{1}{2} + \frac{G}{2(1-G)} \frac{P_x[B \cap npiv] - P_x[A \cap npiv]}{P_x[Piv]} [forall]t$$

When A is candidate,$P_x[B \cap npiv] - P_x[A \cap npiv] = (1-\lambda)(P_0[B \cap npiv] - P_0[A \cap npiv]) + \lambda(2t_n^{*2} - 1) = (1-\lambda)(2t_n^*(2q(1-t_n^*) + t_n^*) + \lambda(2t_n^{*2} - 1)$. Since $(2t_n^*(2q(1-t_n^*) + t_n^*) > (2t_n^{*2} - 1)$, the right hand side decreases with λ. Moreover, for $t_n^* < \sqrt{\frac{1}{2}}$, $2t_n^{*2} - 1 < 1$, therefore, there must be a $\lambda_x \bar(G)$ such that the first condition does not hold. Following the same reasoning as for the director in the network, in that case, the equilibrium has to admit $s_x^* = B$

In both cases, when $s^* = A$ the cut-off points are lower than in the benchmark case since both are negative functions ofλ. Moreover, when both $s^* = B$, there exists a G such that the conditions do not hold and unanimity for A arises. ■

10.4 Optimum comparison

Over the section, I assume that the firm is better off when $W(t) \equiv ((1-q)m_a(t) + q(1-m_b(t)))^3$ is maximized, that is the probability that the three directors make the right decision. Recall that $m_a(t) = 1 - t^2$ and $m_b(t) = (1-t)^2$.

Proof of proposition 7. Since in the efficient case and in the benchmark case all directors are symmetric, it is sufficient to show that $(1-q)m_a(q)+q(1-m_b(q)) > (1-q)m_a(t_0^*)+q(1-m_b(t_0^*))$. It is easy to show that $t = q$ maximizes $(1-q)(1-t^2)+q(2t-t^2)$.
Therefore, $(1-q)m_a(q)+q(1-m_b(q)) > (1-q)m_a(t_0^*)+q(1-m_b(t_0^*))$ holds for all t_0^*. ■

Proof of proposition 8. Since in the efficient case directors are symmetric and that in the network case, directors from the network are symmetric, it is sufficient to show that $(1-q)m_a(q)+q(1-m_b(q)) \geq (1-q)m_a(t_x^*)+q(1-m_b(t_x^*))$ and $(1-q)m_a(q)+q(1-m_b(q)) \geq (1-q)m_a(t_n^*)+q(1-m_b(t_n^*))$ with at least one inequality being strict. In the case with a network but with $G = 0$, $t_x^* = q$ and $t_n^* < q$ for $\lambda > 0$, therefore $(1-q)m_a(q)+q(1-m_b(q)) = (1-q)m_a(t_x^*)+q(1-m_b(t_x^*))$. Besides, $t = q$ maximizes $(1-q)(1-t^2)+q(2t-t^2)$, so $(1-q)m_a(q)+q(1-m_b(q)) > (1-q)m_a(t_n^*)+q(1-m_b(t_n^*))$ ■

Proof of proposition 9. $t = q$ maximizes $(1-q)(1-t^2)+q(2t-t^2)$, therefore, the welfare of the stockholders is maximized for the closest distance of the cut-offs to q. Therefore, to show that $W(t_N^*) > W(t_0^*)$, it is sufficient to show that $(t_n^*-q)^2(t_n^*-q)^2(t_x^*-q)^2 < ((t_0^*-q)^2)^3$. Indeed,

$$W(t_N^*) =((1-q)(1-(t_n^{*2})+q(2(t_n^*-(t_n^{*2}))^2(1-q)(1-t^2)+q(2(t_x^*-(t_x^{*2})$$

$$t_n^* = q+(t_n^*-q) \quad t_x^* = q+(t_x^*-q)$$

$$=> W(t_N^*) = -(t_x^*-q)^2(-(t_n^*-q)^2)^2$$

$$W(t_0^*) =((1-q)(1-(t_0^{*2})+q(2(t_0^*-(t_0^{*2}))^3$$

$$t_0^* =q+(t_0^*-q)$$

$$=> W(t_0^*) =(-(t_0^*-q)^2)^3$$

$$=> W(t_N^*) > W(t_0^*) <=> ((t_0^*-q)^2)^3 > (t_x^*-q)^2((t_n^*-q)^2)^2$$

When $G = 0$ $t_n^* < q$ but as G increases, $t_n^* -> 1 > q$. Therefore, there must be a $\underline{G}(q)$ such that for all $G > \underline{G}(q)$, $tn_q > q$ (and $t_n^* < t_0^*$ and $q < t_x^* < t_0^*$).

Case 1 :$G > \underline{G}$: In that case,, we have $q < t_n^* < t_0^* => (t_0^*-q)^2) > (t_n^*-q)^2)$ and $q < t_x^* < t_0^*$ $=> (t_0^*-q)^2) > (t_x^*-q)^2)$. Therefore, it must be that $((t_0^*-q)^2)^3 > (t_x^*-q)^2((t_n^*-q)^2)^2$ and $W(t_N^*) > W(t_0^*)$

Case2 : $:G < \underline{G}$: In that case, for $W(t^*_N) > W(t^*_0)$ to hold. Either $t^*_n > 2q - t^*_0$, that is, the distance between q and t^*_n is smaller than that between q and t^*_0. Both cut-offs increase in G and in q. When $G = 0$ and $G < \underline{G}(q)$, $t^*_0 = q$, $t^*_n < 2q - t^*_0$ but when $G = \underline{G}(q)$, $t^*_n = q$, $t^*_n > 2q - t^*_0$ Therefore, there must be a $\tilde{G}(q)$ such that $t^*_n = 2q - t^*_0$ and $\tilde{G}(q) < \underline{G}$. When $G > \tilde{G}(q)$, $W(t^*_N) > W(t^*_0)$
If $\bar{G}_0 > \tilde{G}(q)$, then $W(t^*_N) > W(uB)$ ■

Proof of proposition 10. to show that $W(t^*_{N,B}) < W(t^*_0)$, it is sufficient to show that $(t^*_n - q)^2(t^*_n - q)^2(t^*_x - q)^2 > ((t^*_0 - q)^2)^3$
When B is from the network, then $t^*_n > t^*_0 \geq q \Rightarrow (t^*_n - q)^2 > ((t^*_0 - q)^2)^2$ and $t^*_x \geq t^*_0 \geq q \Rightarrow (t^*_x - q) > ((t^*_0 - q)^2)$ so it must be that $W(t^*_{N,B}) < W(t^*_0)$ ■

Proof of proposition 11. $W(t^*_{N,A}) < W(t^*_0)$ When there is unanimity in both cases, B is the elected candidate in the benchmark case and A in the case where A is a candidate from the network. In that case, the equation holds because it is like having $t^*_0 = 1$ and $t^*_n = t^*x = 0$. Since $q > .5$, the distance is farther from q in the network case. When $\lambda = 1$, we have unanimity in the network case (if $G > 0$, otherwise, the directors from the network vote for A and the director who is not randomizes). This too leads to $W(t^*_{N,A}) < W(t^*_0)$ ■

10.5 Extensions

Proof of proposition 12. Going back to (9), it is clear that when you go from 3 to 5 votes, the probability of being pivotal decreases as well as the probability of A being elected when the indifferent director is not pivotal while the probability of B being elected increases. Therefore, we have:

$$\frac{P[B \cap npiv|J = 5] - P[A \cap npiv|J = 5])}{P[piv|J = 5]}$$
$$> \frac{P[B \cap npiv|J = 3] - P[A \cap npiv|J = 3])}{P[piv|J = 3]}$$

So, $t_5^* > t_3^*$.

The same goes by increasing the number of board members from 5 to 7 and so on and so forth. More generally, it is easy to see that $\lim_{J->\infty} P[piv] = 0$, $\lim_{J->\infty} P[A] = 0$ and $\lim_{J->\infty} P[B] = 1$. Therefore, $\lim_{J->\infty} rhs = \infty$. As long as $G > 0$, this leads to a vote of every director for B. It must be that, since the right hand side is increasing in J there is a $\bar{J}$ such that no cut-off equilibrium is sustainable. This $\bar{J}$ solves$\frac{1}{2} + \frac{G}{2(u(A|A)-u(A|B))}\frac{P^*[B\cap npiv|J]-P^*[A\cap npiv|J]}{P^*[piv|J]} = \frac{1}{2}$ for all $G > 0$ ■

Proof of Remark ??. Let G become a function of the votes for the winner $G(\#ofvotes)$. In that case, the indifference equation becomes:

$$P[piv](v(q,s,t)((1-G(2))+G(2))+(1-v(q,s,t))G(2))+(1-P[piv])P[A|npiv]G(3) =$$
$$P[piv]((1-v(q,s,t))(1-G(2))+v(q,s,t)G(2))+(1-P[piv])P[B|npiv]G(3)$$

In the case in which the director is pivotal, he always votes for the winner so the concern cancels out ($G(2)$) and the equlibrium condition becomes:

$$v^*(q,s,t) = \frac{1}{2} + \frac{G(3)}{2((1-G(2)))}\frac{P^*[B\cap npiv] - P^*[A\cap npiv]}{P^*[piv]}$$

So endogenizing G leads to a decrease in the $G/(1-G)$ ratio and unanimity is reached less rapidly. However, it does not change the results in that the ratio is the same in all cases and only alters the intensity of the results. ■

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