Credit Markets, Board Size, and Board Composition

Jack Stecher\textsuperscript{1}  Gorm Grønnevet\textsuperscript{2}

\textsuperscript{1}Carnegie Mellon University, Tepper School of Business

\textsuperscript{2}Norges Handelshøyskole

22 July 2010
We’re interested in corporate governance, in particular in who benefits from having boards vote to approve or reject projects.

We abstract from monitoring or hiring/firing CEOs, and focus on boards as providing expertise. This matches the survey literature:

- Mace (1971)—provide “advice and counsel.”
- Demb and Neubauer (1992)—80% of directors say “setting strategy;” 75% say choosing the company’s overall direction.
- By contrast, 45% mention monitoring as a chief priority, and only 26% mention CEO turnover.

Our focus is on board structure. In particular, insiders and outsiders differ in their expertise:

- Insiders have beliefs about a project’s NPV distribution, but are aware that they are unaware of some states.
- Outsiders do not conjecture a distribution, but imagine a similar case. So they see a draw from the true distribution.

We also investigate the role of board size.
Boards help address asset substitution (Fama/Miller 1972, Jensen/Meckling 1976, Myers 1977).

- Information asymmetries cause outsiders on the board to act as if they represent creditors.
  - Outsider-dominated boards approve projects based on default probabilities, not ENPV.
  - Value-maximizing managers foresee this, and choose projects conservatively when outsiders dominate a board.

The board composition implements the Nash bargaining solution between creditors and shareholders.

- Larger boards also favor creditors’ interests over shareholders’.
- Synopsis: the cost of borrowing falls in outsider control and in board size, but so do expected profits.
Larger board sizes favor creditors over shareholders:
- Coles/Naveen/Naveen (2008): more debt finance $\Rightarrow$ larger boards.

Credit markets like outsider control:

Shareholders worse off with outsider control:
- Perry/Shivdasani (2005): more destruction of positive ENPV projects, deeper staff cuts, more frequent staff cuts.
Timing in the Model

- **Period 1**
  - Stage 0: The firm’s management researches a set of projects $\Theta$, and for each $\theta \in \Theta$ obtains a cost $c_\theta$ of external financing.
  - Stage 1: A risk-neutral manager proposes a project with stochastic outcome $\theta \in \Theta$.
  - Stage 2: Each board member independently evaluates the project.
  - Stage 3: The board votes simultaneously on the project.
  - Stage 4: If the board approves $\theta$, the firm borrows $c_\theta$ at rate $r$. Otherwise, the firm's profit is normalized to 0.

- **Period 2**
  - The project outcome $\theta$ is realized.
  - If $\theta < (1 + r)c_\theta$, the project defaults and the creditors get $\max\{0, \theta\}$.
  - I’ll focus on the case where $\theta \notin (0, (1 + r)c_\theta)$. The reasons will become clear as the talk progresses.
This is a non-Bayesian model, in particular a model with unawareness.

Everyone is risk-neutral, and the manager and board members are just out to maximize shareholder wealth.

The manager conjectures a project-specific distribution $F_\theta$. He knows that $F_\theta$ may differ from the true distribution $G_\theta$).

Board insiders have the same information as the manager.

Board outsiders do not know $F_\theta$ or $G_\theta$, but each observes a single draw $\theta_i \sim G_\theta$.

E.g., if Bill Gates agrees to serve on the board of Jack’s Software Inc., he doesn’t actually research Jack’s projects. He opens the memo, glances at the project, imagines a case, and submits his vote online.

The creditors have the same information as outsiders.
Suppose each outsider reports a signal, and the board approves $\theta$ if and only if the average outsider report is at least $(1 + r)c_\theta$.

**Proposition**

*Truthful reporting is a Nash equilibrium.*

Unfortunately, there are uncountably many other Nash equilibria. We in fact have the following:

**Proposition**

*Suppose there are minimum and maximum admissible reports $\{\theta^h, \theta^l\}$. For convenience, make these equidistant from the threshold $(1 + r)c_\theta$. Then it is a Nash equilibrium to report one of the two extremes; in this equilibrium, everyone plays a weakly dominant strategy.*

Similar results hold if the decision rule is a median report. In that setting, truthful reporting also has everyone play a weakly dominant strategy.
Outsider $i$ wants to support $\theta$ iff it has positive ENPV. Since he only knows $\langle \theta_i, c_\theta, r \rangle$, he votes Yes iff $\theta_i \geq (1 + r)c_\theta$. Ergo,

$$P(i \text{ votes Yes on } \theta) = 1 - G_{\theta}((1 + r)c_\theta).$$

**Proposition (Outsiders)**

*If $k$ outsiders' votes are needed to approve $\theta$ and all $n$ board members are outsiders, then the project is approved with probability*

$$\sum_{j=k}^{n} \binom{n}{j} [1 - G_{\theta}((1 + r)c_\theta)]^j [G_{\theta}((1 + r)c_\theta)]^{n-j}$$

*Hence, the board approves $\theta$ based on its probability of recovering its costs, not on $E[\theta]$.***
Outsider $i$ wants to support $\theta$ iff it has positive ENPV. Since he only knows $\langle \theta_i, c_\theta, r \rangle$, he votes Yes iff $\theta_i \geq (1 + r)c_\theta$. Ergo,

$$P(i \text{ votes Yes on } \theta) = 1 - G_\theta((1 + r)c_\theta).$$

**Example**

Consider two projects, $x$ and $y$, with earnings distributed as follow:

$$x = \begin{cases} 
-11 \ & \text{with probability } \frac{1}{4} \\
4 \ & \text{with probability } \frac{3}{4}
\end{cases}$$

$$y = \begin{cases} 
-3 \ & \text{with probability } \frac{3}{4} \\
13 \ & \text{with probability } \frac{1}{4}
\end{cases}$$
The Outsiders

- Outsider \( i \) wants to support \( \theta \) iff it has positive ENPV. Since he only knows \( \langle \theta_i, c_{\theta}, r \rangle \), he votes Yes iff \( \theta_i \geq (1 + r)c_{\theta} \). Ergo,

\[
P(i \text{ votes Yes on } \theta) = 1 - G_{\theta}((1 + r)c_{\theta}).
\]

Example

Consider two projects, \( x \) and \( y \), with earnings distributed as follow:

\[
x = \begin{cases} 
-11 & \text{with probability } \frac{1}{4} \\
4 & \text{with probability } \frac{3}{4}
\end{cases}
\]

\[
y = \begin{cases} 
-3 & \text{with probability } \frac{3}{4} \\
13 & \text{with probability } \frac{1}{4}
\end{cases}
\]

Note \( E[x] = 1/4 \) and \( E[y] = 1 \), so if \( c_x = c_y \), risk-neutral shareholders prefer \( y \) to \( x \). But \( P(x \text{ defaults}) = 1/4 \), while \( P(y \text{ defaults}) = 3/4 \).
Outsider $i$ wants to support $\theta$ iff it has positive ENPV. Since he only knows $\langle \theta_i, c_\theta, r \rangle$, he votes Yes iff $\theta_i \geq (1 + r)c_\theta$. Ergo,

$$P(i \text{ votes Yes on } \theta) = 1 - G_\theta((1 + r)c_\theta).$$

**Example**

Consider two projects, $x$ and $y$, with earnings distributed as follows:

$$x = \begin{cases} -11 & \text{with probability } \frac{1}{4} \\ 4 & \text{with probability } \frac{3}{4} \end{cases} \quad y = \begin{cases} -3 & \text{with probability } \frac{3}{4} \\ 13 & \text{with probability } \frac{1}{4} \end{cases}$$

If the board consists of 3 outsiders and uses majority rule, then

$$P(x \text{ approved}) = \binom{3}{2} \left( \frac{3}{4} \right)^2 \left( \frac{1}{4} \right) + \binom{3}{3} \left( \frac{3}{4} \right)^3 = \frac{27}{64} + \frac{27}{64} = \frac{27}{32} \ldots$$
Outsider $i$ wants to support $\theta$ iff it has positive ENPV. Since he only knows $\langle \theta_i, c_\theta, r \rangle$, he votes Yes iff $\theta_i \geq (1 + r)c_\theta$. Ergo,

$$P(i \text{ votes Yes on } \theta) = 1 - G_\theta((1 + r)c_\theta).$$

**Example**

Consider two projects, $x$ and $y$, with earnings distributed as follow:

$$x = \begin{cases} 
-11 & \text{with probability } \frac{1}{4} \\
4 & \text{with probability } \frac{3}{4}
\end{cases} \quad y = \begin{cases} 
-3 & \text{with probability } \frac{3}{4} \\
13 & \text{with probability } \frac{1}{4}
\end{cases}$$

However,

$$P(y \text{ approved}) = \binom{3}{2} \left(\frac{1}{4}\right)^2 \left(\frac{3}{4}\right) + \binom{3}{3} \left(\frac{1}{4}\right)^3 = \frac{9}{64} + \frac{1}{64} = \frac{5}{32}.$$
Figure: Dashed line: probability a board of 11 members approves $x$. Solid line: probability a board of 11 members approves $y$. Size of 11: median in Lehn/Patro/Zhao covering data from 1935–2000.
Suppose the fraction $k/n$ of outsiders' votes needed to approve a project is fixed. As $n \to \infty$, then

1. if $1 - G_\theta((1 + r)c_\theta) > k/n$, then $P(\theta \text{ approved}) \to 1$;
2. if $1 - G_\theta((1 + r)c_\theta) < k/n$, then $P(\theta \text{ approved}) \to 0$;
3. if $1 - G_\theta((1 + r)c_\theta) = k/n$, then $P(\theta \text{ approved}) \to \frac{1}{2}$.

At the opposite extreme, suppose $k = n = 1$. Then

$P(\theta \text{ approved}) = 1 - G_\theta((1 + r)c_\theta)$.

In the previous example, if the board size increases from 3 to 11, the probability that $y$ is approved drops from $\approx 16\%$ to $\approx 3\%$. 

Stecher and Grønnevet (CMU and NHH)
Instead of fixing board composition and varying size, we now fix the board size and vary composition. This gives the following:

**Proposition (Board Composition)**

For given board size $n$, let $k > 0$ be the number of outsiders’ votes needed to approve a project. Then the larger $k$ is, the more heavily the board weights creditors’ interests. In particular, the manager’s incentive to maximize shareholder wealth is greatest when $k = 1$. 
The manager must now re-evaluate a project’s ENPV, to incorporate the approval probability. His objective becomes

$$\max_{\theta \in \Theta} P(\theta \text{ approved}) \cdot (E[\theta] - (1 - F_\theta((1 + r)c_\theta))(1 + r)c_\theta).$$

**Theorem**

Suppose $k$ outsiders’ votes are needed to approve a project. As $n$ increases, the manager optimally implements the Nash bargaining solution between a creditor with utility

$$u^c(\theta) = \begin{cases} 
1 & \text{if } P(\theta \geq (1 + r)c_\theta) \geq \frac{k}{n} \\
0 & \text{otherwise}
\end{cases}$$

and a risk-neutral shareholder with utility

$$E[\theta] - P(\theta \geq (1 + r)c_\theta) \cdot (1 + r)c_\theta.$$
Figure: Expected gross value to manager of proposing project $x$ (dashed) and project $y$ (solid) from earlier example, as a function of the number of outsider votes needed for approval, when $n = 11$. 
Figure: Expected gross value to manager of proposing project $x$ (dashed) and project $y$ (solid) from earlier example, as a function of the number of outsider votes needed for approval, when $n = 1000$. 
Since the credit markets do not know $F_\theta$ or $G_\theta$, they face ambiguity. We treat them as following maximin strategies. Generalizations are straightforward.

We have the following results on interest rates:

**Proposition**

*For a large board and a maximin credit market, as $k/n$ increases, $r^*$ decreases. The firm’s profitability may initially increase in the degree of outsider control, but it eventually decreases unless $G_\theta = 0$ a.e.*

Essentially, credit markets are guaranteed that projects pass with probability at least $k/n$, even though they don’t know anything about any specific project.

This determines the equilibrium interest rate (uniquely, by the maximin assumption).
Truthful reporting

- In the voting equilibrium where everyone reports truthfully, everyone votes for the project iff
  \[ E[\theta|\theta_1, \theta_2, \ldots] \geq (1 + r)c_\theta. \]

So board composition is less interesting in this setting. Each informative draw comes from an outsider, but it is the number \( k \) and not the ratio \( k/n \) that matters.

- If the \( \theta_i \) are mutually independent and \( G_{\theta} \) has finite mean and variance, then the central limit theorem gives
  \[
P(\theta \text{ rejected}) = \Phi \left( \frac{(1 + r)c_\theta - E[\theta]}{\sqrt{\frac{\text{Var}[\theta]}{k}}} \right).
  \]
Even though the board gets better information as $k$ increases, the board acts variance-averse.

If the manager were accidentally to propose a project with negative ENPV, the board would act variance seeking.

Both of these tendencies increase in $k$. 
Variance-Aversion

- Even though the board gets better information as $k$ increases, the board acts variance-averse.
- If the manager were accidentally to propose a project with negative ENPV, the board would act variance seeking.
- Both of these tendencies increase in $k$.

Example

Let $\xi, \zeta \in \Theta$ with $\mu = E[\xi] = E[\zeta]$, $c = c_\xi = c_\zeta$, and $\sigma^2_\xi > \sigma^2_\zeta$. Suppose $\mu < (1 + r)c_\xi$. The likelihood ratio of accepting $\xi$ relative to $\zeta$ is

$$LR(\xi, \zeta) := \frac{P(\xi \text{ approved})}{P(\zeta \text{ approved})} = \frac{1 - \Phi \left( \frac{(1+r)c-\mu}{\sigma_\xi \sqrt{k}} \right)}{1 - \Phi \left( \frac{(1+r)c-\mu}{\sigma_\zeta \sqrt{k}} \right)}.$$ 

The numerator approaches $1/2$ from below faster than the denominator. So as $k$ increases, this ratio increases.
• Even though the board gets better information as $k$ increases, the board acts variance-averse.
• If the manager were accidentally to propose a project with negative ENPV, the board would act variance seeking.
• Both of these tendencies increase in $k$.

Figure: The solid curve shows the likelihood of approving a project with variance $2\sigma^2$ relative to a project with variance $\sigma^2$, as a function of $E[\theta] - (1 + r)c_\theta$ over the standard deviation in the vote. The dashed curve shows the same ratio when the riskier project’s variance is $4\sigma^2$. Here the board size $k = 4$. 
Variance-Aversion

- Even though the board gets better information as $k$ increases, the board acts variance-averse.
- If the manager were accidentally to propose a project with negative ENPV, the board would act variance seeking.
- Both of these tendencies increase in $k$.

**Figure:** Likelihood ratios when $k$ increases to 21. The variance-seeking behavior when the project has an expected loss is more dramatic, as the portion of the graph to the left of the $y$-axis is steeper.
Potential creditors will not loan $100,000,000 to a firm in which the entrepreneur has an investment of $10,000. With that financial structure, the owner-manager will have a strong incentive to engage in activities (investments) which promise very high profits if successful even if they have a very low probability of success. If they turn out well, he captures most of the gains, if they turn out badly, the creditors bear most of the costs.

(Jensen/Meckling 1976)

Our view: outsiders (and to some extent large boards) help firms commit to avoiding this asset substitution problem.

⇒ We should see size and outsider control increase in a firm’s reliance on debt finance.