BOARD DIVERSITY AND DISRUPTIVE INNOVATION

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OBJECTIVES

Research question: How does diversity of the director board influence the disruptiveness and novelty of technological innovation at the firm?

Motivation: It is important to answer this question because innovation, especially disruptive technology, stands as a major conduit by which corporations create long-term socioeconomic value for the stakeholders. Disruptive innovation deviates from the prior technological foundation. For example, the accelerated development of mRNA and DNA vaccines for the Covid-19 global pandemic does not follow the technological trajectories of conventional vaccines. Instead, these biotechnology-based vaccines depend on genomics and biochemical methods to synthesize the specific virus protein targets. Although the literature suggests that corporate leadership diversity, including that at the board of directors, is important for firm value creation, its impact on the development of disruptive technological innovation remains under-studied.

Aims:

1. We construct a unique panel data of multi-dimensional board diversity, technological innovation outcomes, firm financial characteristics and measures for corporate governance and management effectiveness.
2. We identify the causal relationship between board diversity and firm innovation.
3. We examine multiple innovation outcomes that reflect different aspects in the development of disruptive technology, including patent count and citation, disruptive technological impact, and economic value.
4. We examine the mechanisms that explain why board diversity may facilitate disruptive innovation by (1) enhancing resource availability, including human, social, and financial resources, (2) improving corporate governance and management effectiveness, and (3) increasing risk tolerance for technological exploration.

DATA

1. Board members' demographic characteristics, educational background, records of serving on other firms' boards, financial expertise and other board characteristics: BoardEx, ExecuComp, and RiskMetrics.
2. Innovation outcomes:

1) Patent counts and citations: PatentView (U.S. Patent and Trademark Office)
2) Disruptive patent citations: Funk and Owen-Smith (2017)

-- Total forward citations of patents that destabilize prior technological trajectories (i.e., reduce subsequent use of the technologies leading to the focal patent)

3) Patent portfolio value: Kogan et al., (2017)

-- Summation of economic value of patents issued in a given firm-year, where a patent's economic value is measured as the product of the stock return due to the value of the patent times the market capitalization of the firm on the day prior to the announcement of the patent issuance.

3. Firm financial characteristics: CRSP/Compustat Merged Database

=> **A panel sample on the U.S. publicly listed firms spanning from 1998 to 2014.**

METHODOLOGY

1. To examine the effect of board diversity on innovation outcomes, we estimate the following specification at the *firm-year* level:

$$\log(y_{i,t}+1) = \alpha_t + \alpha_j + \alpha_z + \gamma * \textbf{Board Diversity}_{i,t} + \beta * X_{i,t} + \epsilon_{i,t}$$

- $y_{i,t}$: # of firm *i*'s patents applied in year *t;* total # of patent citations gained from year *t* to *t+5*; total # of *disruptive* patent citations gained from year *t* to *t+5*; economic value of firm *i*'s patent portfolio in year *t.*
- $\alpha_t, \alpha_j,$ and α_z: year, firm and county fixed effects, respectively.
- $$\textbf{Board Diversity}_{i,t} = \%\ \textbf{of Female}_{i,t} + \textbf{Std. of Age}_{i,t} - \textbf{HHI in Ethnicity}_{i,t} + \textbf{Avg. \# of Other Boards}_{i,t} - \textbf{HHI in Financial Expertise}_{i,t} - \textbf{HHI in Bachelor Institutions}_{i,t}.$$
- $X_{i,t}$: a vector of firm-year characteristics (size, age, market-to-book, ROA, asset tangibility, cash-to-asset, etc.), CEO tenure, board size, whether CEO is the chairman and headquarter county-year characteristics (GDP/capita and GDP growth rate).

2. To identify a causal relationship between board diversity and innovation outcomes, we conduct two-stage least squared analysis. Specifically, we follow Bernile et al. (2018) and instrument $Board\ Diversity_{i,t}$ by the diversity of the supply of potential directors residing one non-stop flight away from the firm headquarters.

BASELINE RESULTS

Table 1. Board diversity and innovation outcomes

	(1)	(2)	(3)	(4)
	Patent count	Patent citation (5-year)	Disruptive patent citation (5-year)	Patent portfolio value
Panel A. OLS				
Board diversity	0.119***	0.145***	0.126***	0.142***
	(3.267)	(3.104)	(2.779)	(3.280)
Panel B. 2SLS				
Instrumented board diversity	0.795**	2.102***	2.447***	2.446***
	(2.000)	(2.759)	(3.071)	(3.270)
Observations	4,842	4,842	4,842	4,842
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
County FE	YES	YES	YES	YES

Note: Standard errors are clustered at the firm level. The corresponding t-statistics are reported in parentheses. *, ** and *** represent 10%, 5% and 1% significance level, respectively.

- Overall, we find strong *positive* effects of board director diversity on innovation outcomes. Specifically, Panel A shows that one standard deviation increase in board diversity is associated with
  - 11.9% increase in the number of patents applied (column 1);
  - 14.5% increase in the number of 5-year forward citations of *all* patents granted (column 2);
  - 12.5% increase in the number of 5-year forward citations of disruptive patents granted (column 3);
  - 14% increase in the economic value of patent portfolio (column 4).
- We find positive and statistically significant effects of board diversity on innovation outcomes when board diversity is instrumented by the diversity of the supply of potential directors residing one non-stop flight away from the firm headquarters (Panel B) .
- Results are qualitatively similar when 1) board diversity is constructed by the principal component analysis; 2) the ratio of R&D expenditure to book assets is included as a control variable; or 3) patent citations are counted within 10 years after issuance.

MECHANISMS

We investigate three potential mechanisms that may explain why board diversity facilitates firm disruptive innovation.

1. **Resource-based mechanism.** We propose that a diverse director board spurs firm innovation by encouraging inter-firm collaborations and relaxing financial constraints. We find evidence that board diversity increases firm engagement in strategic alliances, especially for R&D and technological exploitation.
2. **Governance-based mechanism.** We propose that board diversity fosters firm innovation by appointing upper-echelon managers with high skills and improving the effectiveness of corporate monitoring. Custódio et al. (2019) shows that managers with higher general skills can foster innovation beyond the company's current domain. We provide evidence that firms with high board diversity tend to appoint CEOs, managerial executives, and senior managers with high general abilities.
3. **Risk-based mechanism.** We propose that board diversity promotes firm innovation by increasing its tolerance towards risky investments for long-term value creation—namely, R&D expenditure. We find evidence that firms with high board diversity tend to display high R&D intensity, measured as the ratio of R&D expenditure to book assets.

CONCLUSION

This study examines the effects of board diversity on disruptive innovation at the firm, and the underlying mechanisms for these effects. Using an instrument approach, we identified the causal relationship between board diversity and firm innovation. Specifically, board diversity in demographics and cognitive characteristics can increase the quantity, impact, disruptiveness, and value of firm innovation. We probe resource-, governance-, and risk-based mechanisms to explain the baseline results. We document evidence that a diverse director board spurs disruptive innovation by encouraging inter-firm technological collaborations, appointing skilled upper-echelon managers, and increasing firm risk tolerance to pursue R&D investments.

REFERENCE

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