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Board experiential diversity and corporate radical innovation

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Abstract

Research Summary: How does board experiential diversity affect corporate radical innovation? We find that the combined diversity of directors' educational, industrial, and organizational experiences spurs the quantity and quality of path-breaking patents developed at a firm. Instrumental variable analysis leveraging exogenous variation in firm access to the nonlocal supply of directors with diverse experiences indicates causality, which is corroborated by difference-in-differences tests. Firm heterogeneity suggests experientially diverse directors spur radical innovation by better serving the firm's advisory needs rather than via improved governance. Our findings enrich theoretical insights into how corporate board leadership may affect innovation and long-term value creation at the firm.

Managerial Summary: This study offers practical guidance on director recruitment. Board directors with diverse educational, industrial, and organizational experiences can support the invention of radical technology. This type of innovation can create substantial economic and social value. Noting the benefits of diverse experiences in the boardroom, corporate executives can search beyond the traditional director

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pedigree (e.g., Ivy League-educated financiers), where female and minority individuals remain underrepresented. In doing so, the firm can find more qualified candidates to assemble a demographically and intellectually diverse board, thus cultivating an inclusive corporate culture conducive to shareholder and stakeholder value creation.

KEYWORDS

board advising, experiential diversity, instrumental variable, panel data, radical innovation

1 | INTRODUCTION

How does board experiential diversity affect corporate radical innovation? Modern corporations often emphasize the development of new technologies to gain a competitive advantage, especially by exploration of unchartered technological areas that lead to radical innovation (Fleming, 2007; Manso, 2011). Radical innovation deviates from the prior technological foundation and shifts future researchers' attention away from prior technologies (Balachandran & Hernandez, 2018). This type of innovation provides significant long-term scientific and economic value to "transform the fortunes of organizations and industries" (Funk & Owen-Smith, 2017, p. 791).

Given such import, active research has focused on the potential drivers for radical innovation. At the corporate level, board leadership may play a key role by providing "greater diversity of opinion and expertise outside the manager's competence" (Balsmeier, Fleming, & Manso, 2017, p. 537). That is, a diverse board may foster radical innovation by offering out-of-the-box strategic advice. In line with this notion, evidence shows that a gender and racially diverse board is conducive to R&D investment (Miller & del Carmen Triana, 2009) and that firms with a greater share of female directors tend to achieve higher innovation output and efficiency (Griffin, Li, & Xu, 2021). Yet, centering on demographic diversity, research depicts heightened monitoring (i.e., governance) as a key mechanism by which a diverse board affects firm outcomes (Adams & Ferreira, 2009; Cumming, Leung, & Rui, 2015), while others caution that stringent monitoring may impede firm exploration (Chang, Chen, Wang, Zhang, & Zhang, 2019) and that "weak governance is a necessary evil to stimulate innovation" (Keum, 2021, p. 6). Considering the opposing forces between "out-of-the-box advising" and "heightened monitoring," it may not be clear whether a diverse board can promote radical innovation without scrutiny beyond the directors' demographic backgrounds.

To shed further light on this topic, we examine *board experiential diversity*, which coalesces from the directors' educational, industrial, and organizational experiences. This type of diversity can reflect the board's cognitive abilities to offer unique perspectives (Hewlett, Marshall, & Sherbin, 2013), which are potentially conducive to the creation of radical technology at the firm. In a panel of patenting firms that were publicly listed in the United States from 1996 to 2014, we find that board experiential diversity promotes the quantity and quality of path-breaking patents. To identify causality, we exploit cross-sectional and time-series variations in firm access to the supplies of nonlocal directors with diverse experiences. Namely, our instrument is the experiential diversity of director candidates residing at least 150 miles away but within a nonstop flight to each firm headquarters (HQ) weighed by the frequencies of the director domicile-to-HQ nonstop flights. We corroborate with difference-in-differences (DiD) exploiting a change in Nasdaq and NYSE rules in 2003 that affected corporate board composition. Consistent with our reasoning that unique board advice might explain the radical innovation benefits of diverse director experiences, we find firms with elevated advising needs—rather than those requiring stronger governance—drive the overall effects.

These findings contribute to research on board diversity and corporate innovation. Focusing on an under-examined type of director diversity, we enrich theoretical insights into how board leadership may influence radical innovation and thus long-term value creation at the firm. While prior work shows board demographic diversity to enhance overall R&D efficiency (e.g., Griffin et al., 2021), our evidence shows directors' experiential diversity to foster the high-risk-high-reward types of R&D, such as path-breaking patent invention (Balachandran & Hernandez, 2018; Funk & Owen-Smith, 2017). Our evidence, along with prior findings, implies that distinct types of director diversity affect the firm differently. While diverse shareholder representation may effectuate governance to improve efficiency (e.g., Adams & Ferreira, 2009; Cumming et al., 2015), diverse director experiences may facilitate the board's advisory function to support frontier exploration.

Taken together, executives and shareholders may elect directors with diverse experiences and/or demographic backgrounds depending on the firm's innovation goals and value creation horizons. Keeping in mind the potential benefits of experiential diversity, a firm can search beyond the traditional director pedigree (e.g., Ivy League-educated financiers), where female and minority individuals remain underrepresented, and may also find ease in recruiting demographically diverse directors. In so doing, it is possible to achieve the best of both worlds: electing female and minority directors with unique experiences, who are likely mindful of both current value and future growth.

2 | THEORY

2.1 | Board experiential diversity and radical innovation

Radical innovation refers to inventions that deviate from their predecessors and set new paths for future technology (Balachandran & Hernandez, 2018; Funk & Owen-Smith, 2017). This type of innovation lays the cornerstone for long-term value creation not only for the inventing firm but also for society at large. A prime example is the Covid-19 vaccines developed by companies such as Moderna, BioNTech, and Pfizer. These vaccines rely on sequencing messenger ribonucleic acid (mRNA) and deoxyribonucleic acid—an approach that fundamentally deviates from the established vaccine technology (e.g., collecting, culturing, and attenuating virus strains) and provides a new technological foundation for future vaccine development (Gardner, 2021). Leveraging the mRNA technology, Moderna obtained promising clinical results in its vaccine development for the human immunodeficiency virus in early 2022, which attest to the value of radical technology.

Albeit the potential to yield substantive returns over the long run, radical innovation entails high risks in the short run. To seek opportunities toward radical technology, firms engage in intense exploration at the technological forefront, which is rife with trials and errors and often early failure (Manso, 2011; March, 1991; Singh & Fleming, 2010). Hence, the development of radical innovation requires corporate leadership that is resistant to myopic loss when facing uncertainty (Benartzi & Thaler, 1995) to support firm exploration. To these ends, the board may play a crucial role: directors with an open and long-term oriented mindset can steer the upper echelon to emphasize frontier exploration in the firm's R&D strategy (Balsmeier et al., 2017; Garg, 2013; Hillman & Dalziel, 2003).

Anecdotally, highly innovative firms often value diverse experiences and collective literacy in their boardrooms. For example, Moderna's supervisory board is seated by directors educated in various fields, including business, medical sciences, economics, and journalism.[1] These directors bring years of industry expertise in not only financial investments but also biopharmaceuticals, technology, public policies, and academia. Such board composition echoes Moderna's leadership maxim: "We are creating an inclusive and diverse working environment that encourages and rewards curiosity, collaboration and agility." Taken at face value, experiential diversity in Moderna's boardroom may be a top-down driver for its dedication to and success in radical innovation development.

We argue that a board with diverse educational, industrial, and organizational experiences (Hewlett et al., 2013; Williams & O'Reilly, 1998) may implement the advisory role more effectively compared to directors with uniform experiences, who are more likely to "succumb to groupthink or miss new threats to a company's business model" (Fink, 2018). Namely, strategic guidance from a board with complementary expertise across various domains and settings may help the firm navigate short-term financial, technological, and market uncertainties toward long-term value creation.

First, diverse experiences in the boardroom form the intellectual basis for out-of-the-box strategic thinking (Hillman & Dalziel, 2003; Pfeffer & Salancik, 1978), thus resulting in better advice for firm exploration. Drawing from heterogeneous experiences, the directors can contribute informational variety to combine complementary but otherwise disconnected knowledge pieces, which often results in unique and creative solutions (Dahlin, Weingart, & Hinds, 2005; Eesley, Hsu, & Roberts, 2014; Hambrick, Cho, & Chen, 1996). With fresh perspectives and a wide range of ideas, the directors can help the top management team discover hidden strategic opportunities or create new ones, including those pertinent to the invention of breakthrough technology (Garg, 2013; Mintzberg, Raisinghani, & Theoret, 1976).

Second, experiential diversity assuages group decision biases that hamper exploration, such as herd mentality and heuristic thinking. Informed by diverse expertise, group members provide and incorporate constructive feedback more readily (Barsade, Ward, Turner, & Sonnenfeld, 2000; Mitchell, Nicholas, & Boyle, 2009) and take more varied analytical approaches (Eesley et al., 2014; Hambrick et al., 1996), compared to those with homogenous experiences (Hambrick & Mason, 1984). From a behavioral standpoint, divergent thinking prevents the compounding of individual myopic loss aversion, which is more likely to occur in a homogenous group prone to herd mentality and heuristic thinking (Chrisman & Patel, 2012). Under myopic loss aversion, preferences heighten for short-term returns as uncertainty rises (Benartzi & Thaler, 1995)—a risk attitude diametric to what is supportive of exploration.

Hypothesis. Board experiential diversity spurs radical innovation.

[1]See more details about Moderna's board of directors at https://www.modernatx.com/about-us/leadership.

2.2 | Costs of board experiential diversity

Albeit the potential benefits, we note the caveats of board experiential diversity. As argued above, a cognitively diverse board may encourage the firm to pursue riskier R&D like radical innovation. This risk attitude can reduce R&D efficiency. Enduring early failures in exploration, firms will spend more R&D dollars to reach fruitfulness in technological development. From a socio-cognitive standpoint, experiential diversity can create cognitive and relational frictions against knowledge integration and coordination in a group (Aggarwal et al., 2020; Srikanth & Puranam, 2011). Ineffective integration and coordination among the directors may yield unclear advice on R&D investments, thus exacerbating inefficiency. That is, board experiential diversity may create a mean/variance tradeoff, where firms attain a better chance at developing radical technology at the expense of failing more often.[2]

On the supply side, scarcity of qualified directors with diverse experiences may impose formidable search costs for the firm. For example, directors with scientific or engineering training yet commanding well-versed in corporate strategies are likely scarce and highly sought after. Firms that value experiential diversity may need to expand director search beyond their local supplies and tap into the broader but often less accessible nonlocal director markets, which raises the costs of finding and assembling an experientially diverse board. Conditioned on recruitment, accommodating nonlocal directors can worsen integration and coordination issues, since geographic distance may diminish communication among the directors and/or executives. That is, scarcity of qualified directors can raise the search, integration, and coordination costs of an experientially diverse board, which may erode the value of board experiential diversity.[3]

3 | METHODOLOGY

3.1 | Data and sample

Our sample consists of a panel of listed firms in the United States with one or more patent applications from 1996 to 2014, covering 11,118 firm-year observations of 971 unique firms.[4] The sample starts in 1996 to ensure reliable director records and ends in 2014 to allow at least 5 years of patent forward citations. Following Kogan, Papanikolaou, Seru, and Stoffman (2017), we drop firms with missing book asset value and firms in the financial industries (SIC 6000–6799), utilities (SIC 4900–4949), public administration and non-classifiable business (SIC >9000). Our sample covers all other industries in the Center for Research in Security Prices (CRSP) database (see Table A3 in Appendix I for detailed industry distribution).

[2]R&D inefficiency can proxy failed exploration since early setbacks (e.g., trials and errors that never reached the patenting stage) would elude patent records. We find that firms with higher *board experiential diversity* spend more R&D dollars per granted (path-breaking) patent, suggesting experiential diversity may reduce R&D inefficiency (Appendix III: Panel A, Table A8). Nevertheless, our baseline holds when controlling for R&D expense (Appendix III: Panel B, Table A8).

[3]These arguments are consistent with our IV analysis. For example, an average firm's nonlocal director supply has greater experiential diversity than its local supply does, while physical distance raises the costs of a director seating a firm's board, direct flights offset such costs (see Appendix II). Our instrument exploits these exogenous variations to account for supply-side diversity costs and thus may correct the downward bias in OLS (see Table 2).

[4]We sample firms with at least one patent because radical innovation is undefinable for firms with zero patent.

We combine several data sources to construct our sample. We first collect the characteristics of corporate directors, CEOs, and other managerial executives from BoardEx, RiskMetrics, and Execucomp. We then match the firms to patent assignees in the United States Patent and Trademark Office (USPTO) to collect firm-year patent records. Due to a lack of standardization in the naming of organizational assignees at the USPTO, we rely on corporate name-matching results for U.S. patents by Bena, Ferreira, Matos, and Pires (2017) and Kogan and Papanikolaou (2019). We crosscheck these sources to ensure accurate matching on the patenting firm identities that can be linked to BoardEx and Compustat/CRSP.[5]

To indicate radical innovation, we leverage the *CD index* developed by Funk and Owen-Smith (2017) to identify path-breaking patents in our sample. The *CD index* reflects whether a patent *consolidates* or *destabilizes* extant trajectories of technology development based on the changes in each patent's backward and forward citation networks. Recent studies have adopted the *CD index* and its variants to identify radical innovations (e.g., Azoulay, Fons-Rosen, & Graff Zivin, 2019; Balachandran & Hernandez, 2018; Feng & Jaravel, 2020). Following these studies, we define path-breaking patents as those that destabilize prior technological paths to represent radical innovation. We use Compustat/CRSP data to construct time-varying measures for firm characteristics (e.g., R&D intensity, industry competition, firm complexity, etc.). County-level measures of corporate HQ are gathered from the United States Bureau of Economic Analysis and the Census Bureau. To construct the instrument, we use director domicile data from LexisNexis and nonstop flight data from the Bureau of Transportation and Services.

3.2 | Variables

3.2.1 | Dependent variables

To indicate radical innovation, we identify each firm's path-breaking patents using the *CD index* (Funk & Owen-Smith, 2017). A focal patent's *CD index* at time t is defined in the following equation:

$$CD_t = \frac{1}{n_t} \sum_k \left(-2 f_{kt} b_{kt} + f_{kt} \right), \qquad (1)$$

where $k = (k_1, k_2, \ldots, k_n)$ is the vector of all the subsequent patents citing the focal patent and/or the prior patents cited by the focal patent at time t, n_t is the number of citations to the focal patent and to the prior patents cited by the focal patent, f_{kt} will equal one if k cites the focal patent and zero otherwise, and b_{kt} will equal one if k cites any of the focal patent's prior patents and zero otherwise.

The *CD index* thus captures the degree to which a focal patent increases or decreases the use of prior technological knowledge by subsequent patents—that is, whether a focal patent

[5]Bena et al. (2017) and Kogan et al. (2017) match the USPTO assignees to listed US firms using GVKEY and PERMCO as the firm identifier, respectively. Our sample includes consistent matches between the two, and we use GVKEY to link to the Compustat/CRSP database.

*c*onsolidates or *d*estabilizes the existing technological foundation.[6] Following Funk and Owen-Smith (2017), we identify path-breaking patents in each firm's portfolio of patent applications in a year as those with positive *CD index* based on forward citations within 5 years after patent issuance and all backward citations of a focal patent. *Path-breaking patent count* (*citation*) is the logarithm of one plus the count (5-year forward citation) of all path-breaking patents for which a firm applied in a year.[7]

3.2.2 | Independent variable

We construct a multidimensional index of *board experiential diversity*, which combines the diversity of the directors' educational, industrial, and organizational experiences using records from BoardEx, ExecuComp, and RiskMetrics. Our main theoretical thrust is to depict an experientially diverse board as the basis for out-of-the-box thinking; that is, directors contribute distinct insights and divergent thinking to create (long-term) firm value. Since directors glean insights and cognitive skills from all three types of experiences (Hewlett et al., 2013; Williams & O'Reilly, 1998), an index composed of these acquired diversity dimensions can best proxy the latent constructs of distinct insights and divergent thinking. This approach is consistent with the theory that various facets of diversity jointly shape board decisions (Baranchuk & Dybvig, 2009).[8]

For educational experience diversity, we calculate the additive inverse of the Herfindahl concentration index of the *alma maters* conferring bachelor's degrees to the directors of the firm. We measure the directors' diversity on the level of degree-granting institutions (i.e., schools) to proxy the breadth of social network, school culture, and disciplinary training, all of which contribute to informational variety and divergent thinking in a professional setting.[9] For industrial experience diversity, we calculate the additive inverse of the Herfindahl concentration index of the directors' cumulative work experiences across different industries (three-digit SIC). This aspect reflects the directors' diverse career disciplines and thus exposure

[6]The *CD index* ranges from −1 (most consolidating) to 1 (most destabilizing). For example, both focal patents A and B cited two patents (i.e., predecessors) and have four patent citations after issuance. Suppose that the four patents that cited patent A also cite the two predecessors of patent A and these two predecessors do not have any other citations, then the CD score for patent A is $-1\left(=\frac{1}{4}[(-2\times1\times1+1)+(-2\times1\times1+1)+(-2\times1\times1+1)+(-2\times1\times1+1)]\right)$. Suppose that the four patents that cited patent B do not cite any of the two predecessors of patent B and these two predecessors do not have any other citations beyond patent B, then the CD score for patent B is $1\left(=\frac{1}{4}[(-2\times1\times0+1)+(-2\times1\times0+1)+(-2\times1\times0+1)+(-2\times1\times0+1)]\right)$. In this example, patent A is maximally consolidating, and patent B is maximally destabilizing.

[7]Table A3 in Appendix I provides examples of path-breaking patents and their firm assignees in our sample. Our results are consistent when using highly novel patents to indicate radical innovation, where novelty is defined using the inverse of a patent's textual similarity score (Kuhn, Younge, & Marco, 2020), and highly novel patents are those with novelty scores in top one, five, or ten percentile distribution in each industry-year; in addition to path-breaking (or novel) patent count and citation, our results are consistent when surveying the economic value of these patents (Kogan et al., 2017; Kogan & Papanikolaou, 2019) (available upon request).

[8]Table A9 in Appendix III shows the results from each diversity dimension and from the combined index with one dimension excluded at a time, which reveal no single dimension is solely driving the overall effects.

[9]Regarding disciplinary training, our data source (e.g., BoardEx) does not uniformly report individual majors but indicates school disciplines, for example, director qualification is reported as a degree earned in "Stanford School of Engineering" or "Harvard Business School." However, a degree earned in "Harvard College" (i.e., encompassing liberal arts and sciences) does not indicate whether the director majored in history or chemistry. This deficiency is compensated by the dimension of "industrial experience diversity" in our combined index because a history major would likely work in a different industry than a chemistry major does at some point of their careers.

to different industry- or sector-specific contacts and information, which can broaden a team's knowledge base to enhance its professional functions (Tate & Yang, 2015). For organizational experience diversity, we count the number of other boards on which the directors concurrently place. This facet captures the directors' access to various firm-specific information, organizational culture, and board interlock network, all of which can shape executive decisions (Beckman, Schoonhoven, Rottner, & Kim, 2014; Boeker, 1997; Geletkanycz & Hambrick, 1997), including on the firm's exploration orientation and capacity (Li, 2021; Zucker, Darby, & Brewer, 1998). These dimensions thus complement one another to capture a board's relational, institutional, and functional expertise. We compute *board experiential diversity* as follows:

$$\textit{Board Experiential Diversity} = \textit{Number of Other Boards} - HHI_{\textit{Industrial Expertise}} - HHI_{\textit{Bachelor Institutions}}, \quad (2)$$

where *Number of Other Boards* is the average number of other boards in the Standard and Poor's (S&P) 1500 on which current members serve, $HHI_{Industrial\ Expertise}$ is the Herfindahl concentration index for work experiences across different industries (three-digit SIC), and $HHI_{Bachelor\ Institutions}$ represents the Herfindahl concentration index for the institutions that granted the bachelor's degrees to the board members.[10] We normalize each component by its mean and *SD* to compute the *board experiential diversity* index.[11]

3.2.3 | Control variables

We include a battery of time-varying factors that may bias our estimation of the radical innovation effects from *board experiential diversity*. First, we control for a firm's financial characteristics (e.g., liquidity, market performance and volatility, etc.), which can affect resource allocation toward R&D and thus radical innovation outcomes (Kogan et al., 2017; Lerner & Seru, 2017). *Asset tangibility* is the sum of net property, plant, and equipment and investments divided by book assets. *Cash-to-asset* is cash and short-term equivalents divided by book assets. *Market-to-book* is market equity divided by book equity. *ROA* equals net income divided by book equity. *Firm volatility* is the logged annualized idiosyncratic volatility, which is computed as the square root of 12 multiplied by the *SD* of monthly excess stock returns defined using a Capital Asset Pricing Model estimated over the prior year. *Dividend* equals one if the firm pays dividends in a year and zero otherwise. *Leverage ratio* is the sum of current liabilities and long-term debt divided by the sum of book debt and market equity.

Second, we control for CEO and board characteristics that can affect the involvement and quality of board functions and may thus alter the relationship between director diversity and firm innovation (Bernile, Bhagwat, & Yonker, 2018; Griffin et al., 2021). *CEO chair* equals one if the CEO is also the chair and president of the board and zero otherwise. *CEO tenure* is the

[10]For example, a company has two directors: A and B. A worked in industries 523 and 202 prior to the current year, and obtained a bachelor degree from Harvard; B worked in industry 523 and 545 prior to the current year, and obtained a bachelor degree from Harvard. Then, $HHI_{Industrial\ Expertise} = (2/4)^2 + (1/4)^2 + (1/4)^2 = 0.375$, and $HHI_{Bachelor\ Institutions} = (2/2)^2 = 1$. Since an increase in the Herfindahl concentration index is associated with a decrease in diversity, $HHI_{Industrial\ Expertise}$ and $HHI_{Bachelor\ Institutions}$ have negative signs in Equation (2).

[11]Results are consistent when using PCA to construct the measure of *board experiential diversity* (available upon request).

logarithm of one plus number of years since the current CEO's starting date at a given firm. *Board size* and *director age* are the logarithm of one plus the number of directors and their average age, respectively. Third, we control for firm size and age, which may have mechanical effects on patent count and forward citation (e.g., Lerner & Seru, 2017). *Firm size* is the square root of firm-year employee count.[12] *Firm age* is the logarithm of one plus the number of years since a firm's first appearance in Compustat.

Finally, we control for county factors that can alter board composition (e.g., Bernile et al., 2018) and affect firm radical innovation locally (e.g., resource accessibility). *Local director supply experiential diversity* is the degree of diverse experiences of director candidates who reside within 150 miles of a firm's HQ. *GDP/capita* is the logarithm of one plus per-capita income of a firm's HQ county in a year. *Change in GDP/capita* is the yearly percent change of per-capita income in a firm's HQ county. *Population* is the logarithm of one plus the population of a firm's HQ county. *Change in population* is the yearly percent change of population in a firm's HQ county.[13]

3.3 | Model specifications

We estimate the following regression at the firm-year level to examine the main effects:

$$y_{i,t} = \alpha_t + \alpha_j + \alpha_z + \gamma * Board\ Experiential\ Diversity_{i,t} + \beta * X_{i,t} + \epsilon_{i,t}, \tag{3}$$

where i, t, j, and z denote firms, years, industries, and firm HQ counties, respectively; $Board\ Experiential\ Diversity_{i,t}$ is the standardized index from Equation (2) for firm i in year t; and $X_{i,t}$ is a vector of firm-year controls, including firm characteristics, CEO characteristics, and HQ county-year characteristics. α_t is the year fixed effect that absorbs aggregate shocks affecting all firms, and α_j is the industry fixed effect that absorbs time-invariant industry factors. Including both year- and industry-fixed effects can also alleviate the truncation biases in innovation outcomes (Hall, Jaffe, & Trajtenberg, 2001). α_z is the county fixed effect that absorbs time-invariant, locality-specific biases. We cluster the *SE*s at the firm level.[14]

3.4 | Instrumental variable and two-stage least square tests

Since the selection of board directors is endogenous, we construct an instrument for our key independent variable, *board experiential diversity*, and conduct two-stage least square (2SLS) tests to strengthen causal inferences. Combining BoardEx/Execucomp records with director domicile addresses from LexisNexis and domestic flight data from the Bureau of Transportation and Services, we calculate *nonlocal director supply experiential diversity*, which is the degree of diverse experiences of director candidates who reside at least 150 miles away but within one nonstop flight from a firm's HQ weighted by the frequencies of nonstop flights connecting the firm HQ and director domicile locations.[15] This instrument captures the composition of a firm's

[12]Results are consistent when using the logarithm of one plus employee count (available upon request).

[13]Table A1 in Appendix I provides the definitions of all variables in our analysis.

[14]Results are consistent with lagged regressors or in Poisson models for count outcomes (available upon request).

[15]Director candidates are individuals serving as directors or executives at other firms each year per BoardEx and Execucomp records; only director candidates with home addresses in LexisNexis are included in our instrument calculation since their domicile information is required to define "nonlocal director supply."

nonlocal director supply with cross-sectional and time-series variations exogenously dictated by airline route choices and director residence choices. The validity of this instrument rests on the premise that the experiential diversity of a firm's board is a function of the experiential diversity of the director candidates who are distally accessible to the firm (i.e., relevance), but that the latter will not directly affect the firm's radical innovation or be affected by firm endogeneity (i.e., exclusivity).[16]

Regarding relevance, since a firm's board often consists of both local and nonlocal directors (e.g., Bernile et al., 2018; Knyazeva, Knyazeva, & Masulis, 2013), the firm's *board experiential diversity* will be a function of experiential diversity of the local and nonlocal director supplies. We first define a firm's *local* director supply to consist of director candidates living within 150 miles from the firm's HQ. We then define the firm's *nonlocal* director supply to consist of the remaining domestic director candidates (i.e., living farther than 150 miles from the firm) with reasonable proximity to airports serving nonstop flights to the focal firm's HQ (i.e., within 50 miles, or approximately 1-hr drive, to the closest airport).[17] Experiential diversity of a firm's nonlocal director supply is first computed in Equation (2) vis-à-vis each firm's uniquely defined pool of nonlocal director candidates in a year, and this measure thus varies cross-sectionally and longitudinally in relation to each firm. We then weight this measure by the frequencies of nonstop flights serving between the firm HQ and the nonlocal director domicile airports, because an increase in these nonstop flights will—on the margin—increase the likelihood of the director candidate seating the firm's board.

Regarding exclusivity, the intellectual traits of the nonlocal director supply are likely exogenous to each firm. Prior studies have exploited director supplies to correct endogeneity related to board composition—the logic is that while a firm endogenously determines its board composition, it is unlikely to affect the composition of the external director markets (Knyazeva et al., 2013). While we follow the same intuition, it is nonetheless crucial to exclude local director candidates from the instrument for our research purpose. Local director markets—especially those in technology and industry clusters—may be affected by firm HQ choice and board recruitment effort.[18] Moreover, local director candidates may influence a firm's radical innovation without seating on the firm's board due to local knowledge spillover.[19] That is, experiential diversity of a firm's local director supply may be endogenous and violate exclusivity in our research context. In contrast, nonlocal director markets—those across the nation and beyond daily commutable distances from a focal firm—are not subject to these endogenous pressures.[20] With substantial spatial separation, nonlocal director candidates (and thus their intellectual traits) are unlikely to affect a firm's radical innovation unless they seat the firm's board, and nonstop flight frequencies between director homes and firm HQ are likely to affect radical

[16]Appendix II provides further details of our instrument construction, logic, and evidence on validity.

[17]The median (mean) size of nonlocal director supply pool of a firm in a year is 331 (343) (Appendix II: Table A4).

[18]For example, firms aiming to develop biotechnology breakthroughs cluster in Greater Boston and actively recruit directors with various expertise nearby; this clustering draws intellectually diverse director candidates to move close to Boston, thus altering the composition of the local director supply.

[19]For example, the directors of a focal firm's neighbor firms (e.g., local alliance partners) may communicate with the focal firm's directors or executives regarding technology development, which may affect the focal firm's radical innovation outcomes. We control for *local director supply experiential diversity* in all our models.

[20]It is hard to argue any firm would have substantive influence over director supplies across the United States even considering only locations with nonstop flight connectivity to the focal firm. For example, the experiential diversity distributions are fundamentally different between the actual board, local, and nonlocal director supplies of a firm in a year in our sample (Appendix II: Tables A5 and A6).

innovation only via board placement. We set the cutoff distance to 150 miles as a conservative threshold to assuage endogeneity.[21]

4 | RESULTS

Table 1 presents the summary statistics of our firm-year level panel: Panel A reports radical innovation outcomes, Panel B shows board characteristics, Panels C and D disclose other time-varying firm and county attributes (see Table A2 in Appendix I for pairwise correlations). Consistent with our expectations, path-breaking innovation outcomes are skewed toward zero. In our sample, 65 out of 971 firms with at least 1 patent from 1996 to 2014 (or about 30% of the 11,118 firm-year observations) had zero path-breaking patents.

Figure 1 plots the firm-year averages of *path-breaking patent count* (upper panel) and *citation* (lower panel) against *board experiential diversity* deciles. The upward trends indicate that firms with a higher degree of board diversity are associated with better radical innovation outcomes. On average, firms within the bottom decile of board experiential diversity have 3 path-breaking patents and 20 citations per year, while the ones within the top decile have 63 path-breaking patents and 454 citations per year.

Table 2 reports the estimated effects of *board experiential diversity* on *path-breaking patent count* and *citation* using OLS (Panel A) and 2SLS (Panel B) models. In Panel A, the estimated coefficients of *board experiential diversity* are positive and statistically significant above the 99% confidence level (i.e., $p = .000$) in both columns. The estimated effects show economic significance: 1 *SD* increase in *board experiential diversity* is associated with a 13.5% increase and a 19.4% increase in *path-breaking patent count* and *citation*, respectively. Based on the sample mean, these increases are equivalent to gaining 3 additional path-breaking patents and 29.5 additional citations for these patents (or about 10 citations per path-breaking patent) by a firm in a year.

In Panel B, Column 1 reports the first-stage results. The effect of the instrument, *nonlocal director supply experiential diversity*, on the endogenous predictor, *board experiential diversity*, is positive and statistically significant above the 99% confidence level ($\beta = .133$, $p = .000$). The Kleibergen–Paap Wald rk F statistic is 21.315 (i.e., above the accepted threshold of 10 for instrument strength). These results show that the instrument is relevant and strong.[22] Columns 2 and 3 report the second-stage estimates, showing the instrumented *board experiential diversity* to yield positive and statistically significant impacts on *path-breaking patent count* ($\beta = 1.511$, $p = .000$) and *citation* ($\beta = 2.172$, $p = .000$). For each firm-year, 1 *SD* diversity increase yields 34 more path-breaking patents and 330 more citations (or about 10 more citations per path-breaking patent) based on the sample mean.

[21]The U.S. Department of Transportation estimates that 95% of vehicle trips are within 30 miles. Then, 150 miles thus safely excludes director candidates who can reasonably commute to a firm HQ. It is also large enough to evade endogeneity related to technology/industry clusters. For example, the average radius of the San Francisco Bay Area is about 47 miles, and that of the San Jose-San Francisco-Oakland Combined Area is about 57 miles.

[22]Appendix II provides further statistics and test results on instrument relevance. For example, diversity in the nonlocal director supply is greater than that in the local supply for each firm-year (Table A5); additionally, director-firm physical distance reduces the likelihood of a director seating a firm's board (i.e., increased costs), but nonstop flight frequency between each director-firm county pair offsets such cost increase (Table A7). These results suggest that experiential diversity in a firm's board will likely increase when it searches beyond the local director market, such as when the firm is well-connected to the wider nonlocal director markets via nonstop flights.

TABLE 1 Summary statistics. The table reports the descriptive statistics of key variables in the baseline sample, which includes 11,118 nonfinancial and nonutility firm-year observations in the intersection of the following databases: RiskMetrics, ExecuComp, Compustat/CRSP, BoardEx, and USPTO PatentView. We also collect data on innovation outcomes from Funk and Owen-Smith (2017). The sample spans from 1996 to 2014 and is limited to the firms with at least one patent application each year. Panels A–D report summary statistics for firm-year-level radical innovation outcomes, corporate board time-varying characteristics, other firm-level time-varying characteristics, and time-varying characteristics of firm headquarters counties, respectively. All variable definitions are provided in Table A1. Pairwise correlations between all variables in the OLS and the second stage of 2SLS analysis are provided in Table A2

Panel A. Corporate radical innovation outcome	**Mean**	***SD***	**25th percentile**	**Median**	**75th percentile**
Path-breaking patent counts	22.37	115	0	2	9
Path-breaking patent citations (5-year)	151.9	837.5	0	9	52
Panel B. Corporate board characteristics	**Mean**	***SD***	**25th percentile**	**Median**	**75th percentile**
Board experiential diversity	0	1	−0.557	0.125	0.66
Bachelor institution HHI	0.211	0.152	0.125	0.167	0.25
Industrial expertise HHI	0.482	0.241	0.306	0.406	0.556
Mean number of other boards	1.75	1.04	1	1.619	2.286
Average director age	59.62	4.661	57.13	60.2	62.71
Board size	9	3	7	9	11
Panel C. Other firm characteristics	**Mean**	***SD***	**25th percentile**	**Median**	**75th percentile**
Nonlocal director supply experiential diversity	0	1	−0.303	0.052	0.463
Asset tangibility	0.287	0.177	0.154	0.251	0.381
Cash-to-asset	0.216	0.208	0.0495	0.145	0.328
CEO Chair (Y/N)	0.942	0.234	1	1	1
Dividend (Y/N)	0.483	0.5	0	0	1
CEO tenure	5.195	5.463	2	4	7
Firm size (employment in thousand)	17.39	36.55	1.128	4.457	14.7
Firm age	27.01	17.97	12	21	43
Firm volatility	0.339	0.148	0.245	0.349	0.349
Market-to-book	5.945	63.34	1.691	2.693	4.545
Leverage ratio	0.239	0.179	0.0964	0.202	0.341
ROA	−0.015	7.85	0.02	0.11	0.186
Panel D. County characteristics	**Mean**	***SD***	**25th percentile**	**Median**	**75th percentile**
Local director supply experiential diversity	0	1	−0.398	0.163	0.608

TABLE 1 (Continued)

Panel D. County characteristics	Mean	*SD*	25th percentile	Median	75th percentile
GDP per capita ($)	44,508	12,077	34,868	43,332	53,433
Change in GDP/capita (%)	3.492	4.284	1.025	3.847	6.046
Population	737,394	280,252	717,926	717,926	1,061,709
Change in population (%)	6.247	51.58	0	11.67	11.67

Abbreviation: 2SLS, two-stage least square.

While the 2SLS and OLS results are qualitatively consistent, it is noteworthy that the magnitudes of IV estimates are larger than the OLS estimates. Part of this discrepancy can be explained by the unobserved diversity costs (e.g., those discussed in Section 2.2) for which the OLS models fail to correct, thus producing estimates that are biased toward zero. Specifically, OLS models estimate the average treatment effect (ATE) by exploiting the natural variations across all firm-years. This estimation does not precisely correct for the comparability between treated firms and their counterfactuals (i.e., firms with high vs. low *board experiential diversity*). In our case, ATE would be biased toward zero in OLS models when some firms in the full sample select against diversity because they do not value radical innovation above the costs of assembling an intellectually diverse board.

In contrast, 2SLS estimates reflect the impact of diversity at a firm conditioned on the costs of tapping into its nonlocal director markets. Specifically, IV analysis consistently estimates the local ATE (LATE) in a sub-sample of firms whose endogenous variable is sensitive to the instrument. In our case, the 2SLS results are driven by firms whose *board experiential diversity* relies on the diversity in nonlocal director markets that are accessible to the firms—or firms who value intellectual diversity above the added costs of a nonlocal director search compared to a local search.[23] Our IV thus captures the diversity costs resulting from scarcity in the firm's local director supply and corrects some of the downward bias of the OLS estimates.

While the 2SLS analysis helps establish causality and address omitted variable biases, it is necessary to note that LATE may not apply to the whole population, and one must exercise caution when interpreting its economic magnitude. Our LATE is mainly representative of firms that tap into the nonlocal director markets, and these firms likely have more experientially diverse boards than average. We note that in our sample, firm-year observations in the upper deciles of *board experiential diversity* appear to have a more rapid increase in radical innovation than those in the lower deciles (see Figure 1). Hence, the LATE may be closer to the upper bound of the true effect size, whereas the ATE may be closer to the lower bound. To mitigate concerns over the generalizability of our 2SLS results, we will deploy an alternative identification strategy in our robustness tests below.

[23]On average, experiential diversity is higher in a firm's nonlocal supply than in its local supply of potential directors (Appendix II: Table A5), suggesting the costs of assembling an intellectually diverse board in part stem from broadening director recruitment (e.g., scarcity in local supplies); these costs increase in physical distance but are mitigated by nonstop flight connectivity between firm HQ and director domiciles (Appendix II: Table A7).

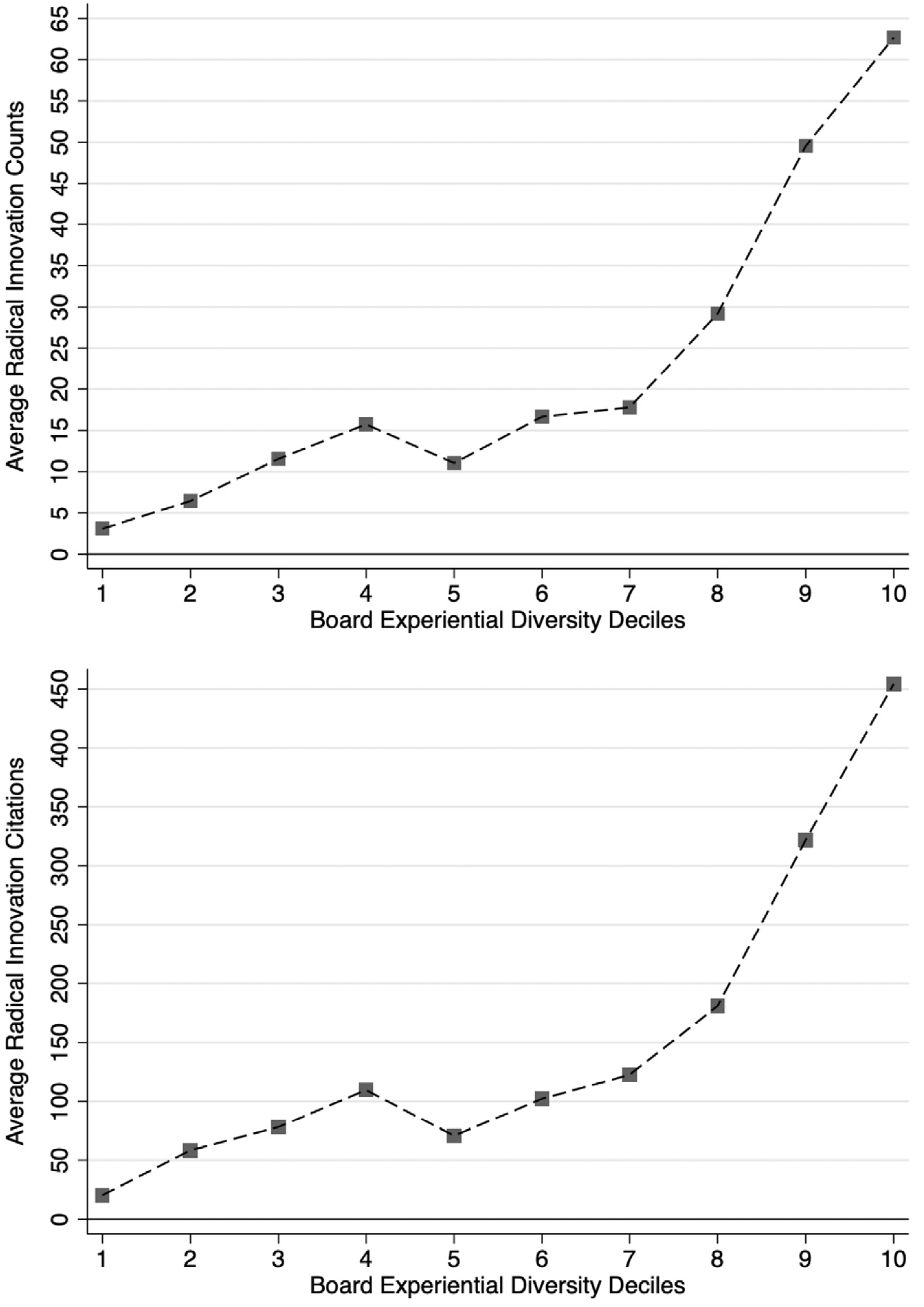

FIGURE 1 Average radical innovation counts and citations. The figure shows the plots of average radical innovation counts (upper panel) and citations (lower panel) against the deciles of *board experiential diversity* (defined in Equation (2)) at the firm-year level.

5 | ROBUSTNESS TESTS

In this section, we test the robustness of our main findings. First, we adopt an alternative identification strategy to corroborate our IV analysis. We conduct DiD with firm fixed effects using

TABLE 2 Board experiential diversity and radical innovation. The table presents the OLS (Panel A) and 2SLS (Panel B) regression estimates of the main effects of board experiential diversity on path-breaking innovation at the firm. In the 2SLS models, *board experiential diversity* is instrumented with *nonlocal director supply experiential diversity*, or the weighted mean experiential diversity of nonlocal potential directors residing one nonstop flight away from the firm headquarters, where the weight is the frequency of nonstop flights connecting director residence and firm headquarters locations. All regressions control for time-varying firm and county characteristics, year, industry, and headquarters county fixed effects. The coefficient estimates of the control variables are suppressed for brevity. Robust *SE*s are clustered at the firm level. The corresponding *p* values are reported in parentheses. The sample description is in the legend in Table 1. All variables are defined in Table A1

Panel A: OLS

	(1)	(2)
Dependent variable	**Ln(1 + Path-breaking patent counts)**	**Ln(1 + Path-breaking patent citation) (5-year)**
Board experiential diversity	0.135 (.000)	0.194 (.000)
Observations	11,118	11,118
R-squared	.590	.598
Firm, CEO, board, and county controls	Yes	Yes
Industry (three-digit SIC) FE	Yes	Yes
Year FE	Yes	Yes
Industry (three-digit SIC) FE	Yes	Yes
HQ county FE	Yes	Yes

Panel B: 2SLS

	First stage	Second stage	
	(1)	(2)	(3)
Dependent variable	**Board experiential diversity**	**Ln(1 + Path-breaking patent counts)**	**Ln(1 + Path-breaking patent citation) (5-year)**
Instrumented board experiential diversity		1.511 (.000)	2.172 (.000)
Nonlocal director supply experiential diversity	0.133 (.000)		
Observations	11,118	11,118	11,118
Kleibergen–Paap Wald rk F statistic	21.315		
R-squared		0.568	0.629
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Industry (three-digit SIC) FE	Yes	Yes	Yes
HQ county FE	Yes	Yes	Yes

Abbreviation: 2SLS, two-stage least square.

new listing rules issued in 2003 by the NYSE and the NASDAQ, which require a majority board to be independent directors. This regulation shift has imposed board composition changes in firms that were noncompliant prior to 2003, thus resulting in exogenously induced variations in *board experiential diversity* among these firms after 2003. *Noncompliance* is a binary variable that equals one for noncompliant firms (i.e., treated) and zero for compliant firms (i.e., control). To select control firms, we first match compliant firms with treated firms on their three-digit SIC codes. Among those matched firms, we then select five controls with the closest firm size measured by employment given the fact that *firm size* is positively correlated with *board experiential diversity* and radical innovation outcomes. *Post* equal one for years including and after 2003 and zero otherwise.

In Column 1 of Table 3, the coefficient of *Noncompliance* × *Post* shows that, on average, *path-breaking patent count* increase by 39.4% (about 8.8 more patents than the mean) for noncompliant firms after implementing the new listing rules; the coefficient of *Noncompliance* × *Post* × *Board experiential diversity* indicates that, among those noncompliant firms, 1 *SD* increase in *board experiential diversity* after the enactment of new listing rules is associated with an additional 34% increase in radical innovation counts (adding another 7.6 patents). Column 2 shows that, on average, *path-breaking patent citation* increases by 44.9% (about 68.2 more citations than the mean) for noncompliant firms after implementing the new listing rules. Among the noncompliant firms, 1 *SD* increase in *board experiential diversity* after the enactment of new listing rules is associated with an additional 35.2% increase in *path-breaking patent citation* (adding another 53.5 citations). That is, an exogenously induced change of *board*

TABLE 3 Alternative identification strategy: new listing rules. The table reports difference-in-differences tests with firm-fixed effects. The sample is balanced and only includes firms that have 2 years of data before and after 2003. The dependent variables are the logarithm of one plus the number of patent counts (Column 1) and 5-year forward citations (Columns 2) of each firm-year's path-breaking patents. Both models include independent director share, all time-varying controls in Table 2, year-fixed effects, and firm-fixed effects. Robust *SE*s are clustered at the firm level. The corresponding *p* values are in parentheses

	(1) Ln(1 + Path-breaking patent counts)	(2) Ln(1 + Path-breaking patent citation) (5-year)
Board experiential diversity	0.080 (.063)	0.128 (.090)
Post × board experiential diversity	−0.022 (.421)	−0.044 (.363)
Noncompliance × board experiential diversity	−0.277 (.141)	−0.212 (.443)
Noncompliance × post × board experiential diversity	0.349 (.001)	0.449 (.002)
Noncompliance × post	0.394 (.002)	0.352 (.107)
Independent director share	−0.321 (.224)	−0.992 (.031)
Observations	2,400	2,400
R-squared	.912	.862
Controls	Yes	Yes
Year FE	Yes	Yes
Firm FE	Yes	Yes

TABLE 4 Board experiential and demographic diversity horse race. The table reports horse race models that include both *board experiential* and *demographic* diversity. All regressions control for time-varying firm and county characteristics, year, industry, and headquarters county fixed effects. The coefficient estimates of the control variables are suppressed for brevity. Robust *SE*s are clustered at the firm level. The corresponding *p* values are in parentheses. *Board demographic diversity* is the linear combination of each firm-year's diversity in the directors' gender, race, and age

	OLS		**2SLS**	
	(1)	**(2)**	**(3)**	**(4)**
	Ln(1 + Path-breaking patent counts)	**Ln(1 + Path-breaking patent citation) (5-year)**	**Ln(1 + Path-breaking patent counts)**	**Ln(1 + Path-breaking patent citation) (5-year)**
Board experiential diversity	0.134 (.000)	0.192 (.000)	1.5007 (.0000)	2.1580 (.0000)
Board demographic diversity	−0.013 (.550)	−0.033 (.281)	0.0735 (.1348)	0.0929 (.1716)
Observations	11,118	11,118	11,118	11,118
R-squared	.590	.598	.573	.633
Controls	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry (three-digit SIC) FE	YES	YES	YES	YES
HQ county FE	YES	YES	YES	YES

Abbreviation: 2SLS, two-stage least square.

experiential diversity is associated with radical innovation improvements at the firm. The DiD results thus corroborate our main findings.

Second, we include *board demographic diversity* as an additional control variable. Scholars have conjectured that directors with diverse demographic backgrounds may bring unique insights and thus promote innovation (Griffin et al., 2021; Miller & del Carmen Triana, 2009). It is thus crucial to exclude an omitted variable bias: directors' demographic backgrounds but not their experiences are driving our results. *Board demographic diversity* is the linear combination of each firm-year's diversity in the directors' gender, race, and age. In Table 4, the effects of *board experiential diversity* continue to hold, but the effects of *board demographic diversity* are null. Thus, *board demographic diversity* is unlikely an omitted variable that could make our findings spurious.[24]

[24]We caution that null effects here do not indicate no impact from *board demographic diversity* since they could be explained by insufficient statistical power such as low variance of *board demographic diversity*. That said, we note the VIFs of *board demographic* and *experiential diversity* are 1.5 and 1.94, respectively, which help mitigate concerns over multicollinearity. Another possibility is a nonlinear relationship between *board experiential diversity* and *path-breaking patent count/citation*, which appears in our raw data (plots available upon request).

6 | MECHANISM TESTS

In this section, we examine firm heterogeneity in the effects of board experiential diversity on radical innovation to understand the potential mechanism that underlines our findings. While our deductive thoughts invoke the board's advisory role (i.e., directors with diverse experiences may offer unique perspectives), boards are concurrently tasked with monitoring responsibilities. To distinguish between these two major board functions, we first test the moderation effects of industry competition. Under high competition, the board's advising role is prominent because firms often need strategic guidance to optimize resource allocation and defend against threats (Pfeffer, 1972). Prior research also finds industry competition can mitigate managerial slack and thus substitute governance measures such as board monitoring; in contrast, under low competition, firms control monopoly power, which often spawns agency problems and thus heightens the need for board monitoring (Giroud & Mueller, 2010). Therefore, if the overall effects are driven by firms facing high (low) industrial competition, we may infer that the board's advising (monitoring) role may explain the baseline. We measure industrial competition as the reverse of the Herfindahl–Hirschman Index (HHI), constructed using firm market share in sales. We create tercile indicators of competition and interact *board experiential diversity* with the second and the third terciles (i.e., *Mid_Competition* and *High_Competition*).

Columns 1 and 2 in Table 5 report the 2SLS estimates of these interaction effects. We find firms in more competitive industries gain greater radical innovation benefits from *board experiential diversity*. Based on the sample means, 1 *SD* increase in *board experiential diversity* yields 3 more path-breaking patents and 223 more citations for firms facing the highest competition (i.e., the third tercile of industry competition, or *High_Competition*) than it does for firms facing the lowest competition (i.e., the first tercile). The differences are economically and statistically significant ($p < .1$).

To strengthen the inferences on board advising, we examine moderation by firm complexity, which indicates the degree of a board's advisory involvement. Specifically, the literature suggests complex firms demonstrate greater advising needs from the board than simple firms do (Coles et al., 2008; Klein, 1998). Hence, if the overall effects are driven by highly complex firms, we may infer it is the board's advising role that explains the baseline. Following Coles et al. (2008), we calculate the complexity score as the first component of firm revenue, leverage ratio, and firm employment in principal component analysis (PCA). The rationale behind the complexity score calculation is that firms of bigger sizes (e.g., revenue), more dependence on external resources (e.g., leverage), and broader scopes (e.g., employment) tend to solicit more strategic advising from their boards (Coles et al., 2008; Klein, 1998; Pfeffer, 1972). We create tercile indicators of firm complexity and interact *board experiential diversity* with the second and the third terciles (i.e., *Mid_Complexity* and *High_Complexity*). Columns 3 and 4 in Table 5 report the 2SLS estimates of these interactions. We find that *board experiential diversity* interacts positive and statistically significantly with both *Mid_Complexity* and *High_complexity*; moreover, the latter yields larger interaction effects than the former does for both radical innovation outcome measures. These results suggest that the more complex firms gain greater radical innovation benefits from diverse director experiences.

Finally, we probe moderation by monitoring to understand whether this board function could also explain the radical innovation benefits of diverse director experiences. If the overall effects are driven by the firms that lack monitoring, it may indicate that *board experiential diversity* spurs radical innovation through improving governance. Research suggests independent directors raise monitoring strength (e.g., Faleye, Hoitash, & Hoitash, 2011). We thus proxy

TABLE 5 Mechanism: board advisory or monitoring? The table presents the 2SLS estimations of firm heterogeneity patterns to reveal whether the effects of *board experiential diversity* on radical innovation are underpinned by the directors' advisory or monitoring role. In Columns 1 and 2, instrumented *board experiential diversity* is interacted with indicator variables that indicate whether the firm is in the second or third terciles of the sample distribution of *Industry Competition*. In Columns 3 and 4, instrumented *board experiential diversity* is interacted with indicator variables that indicate whether the firm is in the second or third tercile of the sample distribution of *Complexity*. In Columns 5 and 6, instrumented *board experiential diversity* is interacted with indicator variables that indicate whether the firm is in the first or second tercile of the sample distribution of *Monitoring*. Board diversity and cross-sectional indicator variables are estimated but not reported for brevity. All regressions control for time-varying firm and county characteristics, year, industry, and headquarters county fixed effects. The coefficient estimates of the control variables are suppressed for brevity. Robust *SE*s are clustered at the firm level. The corresponding *p* values are in parentheses

	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(1 + Path-breaking patent counts)	**Ln(1 + Path-breaking patent citation) (5-year)**	**Ln(1 + Path-breaking patent counts)**	**Ln(1 + Path-breaking patent citation) (5-year)**	**Ln(1 + Path-breaking patent counts)**	**Ln(1 + Path-breaking patent citation) (5-year)**
Board experiential diversity × Mid_Competition	0.085 (.233)	0.462 (.275)				
Board experiential diversity × High_Competition	0.131 (.091)	1.469 (.036)				
Board experiential diversity × Mid_Complexity			0.910 (.031)	1.021 (.086)		
Board experiential diversity × High_Complexity			1.300 (.009)	1.352 (.047)		
Board experiential diversity × Low_Monitoring					−0.197 (.448)	−0.315 (.363)
Board experiential diversity × Mid_ monitoring					−0.189 (.460)	−0.314 (.351)
Observations	11,118	11,118	11,118	11,118	11,118	11,118
R-squared	.546	.339	.334	.447	.296	.436
Firm, CEO, board and county controls	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry (3-digit SIC) FE	YES	YES	YES	YES	YES	YES
HQ county FE	YES	YES	YES	YES	YES	YES

Abbreviation: 2SLS, two-stage least square.

board monitoring by the share of independent directors and create tercile indicators based on its sample distribution. We interact *board experiential diversity* with the first and second terciles of independent director shares (i.e., *Low_ Monitoring* and *Mid_Monitoring*). Columns 5 and 6 in Table 5 report the 2SLS estimates of these interactions. Relative to firms in the third terciles of independent director share (i.e., high board monitoring), the effects of *board experiential diversity* on radical innovation do not appear to be different at firms with low or medium board monitoring (*p* values range from .351 to .460). Therefore, we do not find evidence that experiential diversity would promote radical innovation through improving governance.[25]

7 | DISCUSSION

This study presents empirical evidence of a positive relationship between board experiential diversity and corporate radical innovation. We show that experientially diverse boards may promote the quantity and quality of path-breaking patents, which can yield substantive long-term value not only for the innovating firm but also for relevant industries and society at large (Funk & Owen-Smith, 2017). Our findings contribute to research on board diversity and corporate innovation. Focusing on experiential diversity—a type of director diversity that deserves much more attention—and radical innovation that entails high R&D risks, our analysis complements prior work that highlights board demographic diversity as a corporate driver for overall R&D input, output, and efficiency (e.g., Griffin et al., 2021; Miller & del Carmen Triana, 2009). Our evidence also suggests board experiential and demographic diversity may accentuate distinct functions. Our main effects appear more prominent at firms with elevated advising needs (e.g., in fragmented industries) than at firms facing heightened board monitoring (e.g., in concentrated industries). This heterogeneity pattern suggests experientially diverse boards spur radical innovation via advising instead of monitoring, whereas the latter is often attributed to the impacts of demographically diverse boards (Adams & Ferreira, 2009; Cumming et al., 2015).

On the practical front, this study yields actionable guidance on board composition. Our findings, when viewed along with prior studies on board demographic diversity, imply that corporate executives and shareholders may prioritize diverse director experiences and/or demographic backgrounds considering the firm's advisory and governance needs, which can be shaped by its innovation goals and value creation horizons. For example, while demographically diverse directors may improve governance to yield immediate benefits such as higher R&D efficiency, those with complementary expertise across various domains may offer unique advice to support radical innovation toward long-term value creation. While there can be tension between short- and long-term value creation, it is not irreconcilable. Firms can potentially achieve the best of both worlds by recruiting female and minority directors with nontraditional experiences, who are likely mindful of both current shareholder value and future growth opportunities.[26] One potential path to overcome scarcity is to look beyond the traditional director pedigree (e.g., Ivy League-trained financiers), where females and visible minorities remain underrepresented.

[25] All interaction effects are consistent when estimated using OLS models (results available upon request).

[26] Consistent with this notion, recent research points out that, due to the differences between female and male individuals in risk assessment and mitigation, firms with more female directors tend to achieve higher R&D efficiency (Griffin et al., 2021). In our sample, firms with more intellectually diverse directors tend to show *lower* R&D efficiency (Appendix III: Table A8). It is plausible that a firm can strike a balance by selecting for both inherent and acquired diversity when assembling its board.

We note an important caveat for interpreting our results. Namely, our IV and OLS estimates show a nontrivial discrepancy in magnitudes. This discrepancy is in part due to negative biases in the OLS estimators associated with unobserved diversity costs. However, one must exercise caution when interpreting the economic significance of our IV estimates because they capture the subsample LATE rather than the full sample ATE. Our LATE likely represents firms that value diverse experiences above the added costs of a nonlocal director search and thus have above-average board experiential diversity. These firms might prioritize radical innovation more than an average firm does (e.g., in our sample, firm-years in the upper deciles of diversity show greater increases in radical innovation than those in the lower deciles). The true effect size of board experiential diversity on radical innovation is likely somewhere between our OLS and IV estimates.

Nevertheless, our findings highlight the value of diverse experiences in the boardroom. We encourage follow-on research to scrutinize the costs of board experiential diversity. For instance, we find that experiential diversity in the boardroom may create a mean/variance tradeoff where firms achieve greater success in radical innovation at elevated costs (i.e., lower R&D inefficiency) potentially due to early failures. Meanwhile, external factors such as the institutional environment and inter-organization networks can alter the innovation costs and benefits of internal drivers such as leadership structure and governance (Genin, Tan, & Song, 2021; Genin, Tan, & Song, 2022). Corporate strategic actions such as mergers and acquisitions (M&As) can also affect new technology investment and integration (Ma, Ouimet, & Simintzi, 2022). Scholars can explore how external conditions and/or strategic actions may shape the innovation mean/variance tradeoff of board experiential diversity. Another worthy avenue is to explore each type of board experiential diversity separately. Our results depict the combination of directors' educational, organizational, and industrial experiences, yet each experience may drive board functions and firm outcomes differently. We leave these and other quests to future research.

8 | CONCLUSION

In conclusion, we find empirical evidence on the benefits of board experiential diversity for corporate radical innovation. The evidence is consistent with our conjecture that an experientially diverse board spurs radical innovation by offering unique perspectives (e.g., advising), whereas we find no support that board monitoring would explain our observations. Although echoing prior research that shows stringent governance might stifle innovation, our findings do not imply board experiential diversity would systematically reduce monitoring. Instead, diverse director experiences likely yield intellectual resources to support radical innovation toward long-term value creation at the firm.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request with a few exceptions due to third-party restrictions. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the corresponding author with the permission of the licensing third-party of each data source: (1) BoardEx. (2) ExecuComp. (3) UVA Darden Global Corporate Patent Dataset. (4) Compustat/CRSP. (5) Lexis Nexis. (6) SDC Platinum.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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