

Has corporate culture of innovation improved or diminished over time? Insights from textual analysis and board composition

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Abstract

Purpose – This study examines the evolution of corporate innovation culture, focusing on how board independence and gender diversity impact this trend. It seeks to determine whether innovation culture has strengthened over time and to identify the role of board composition in fostering innovation.

Design/methodology/approach – Using a text-based metric from Li *et al.* (2021), this study analyzes over 50,000 firm-year observations. Temporal trend analysis and regression modeling assess shifts in innovation culture, with a focus on the moderating effects of independent and gender-diverse boards.

Findings – The findings reveal a positive trend in corporate innovation culture, supporting the “innovation surge hypothesis.” Independent directors are shown to enhance long-term strategic thinking, while gender-diverse boards contribute varied perspectives, strengthening the culture of innovation.

Originality/value – This study employs the machine learning-based approach developed by Li *et al.* (2021) to measure corporate innovation culture, providing fresh insights into how board diversity and independence sustain innovation. By leveraging this novel method, we contribute to the understanding of corporate governance’s role in fostering long-term innovative growth.

Keywords Corporate innovation, Board independence, Gender diversity, Text-based metric, Machine learning, Temporal dynamics, Time trends

Paper type Research article

1. Introduction

In today’s dynamic global economy, corporate innovation is fundamental to sustained growth and competitive advantage. It enables firms to adapt to technological change, evolving consumer preferences, and intense market competition. Innovation extends beyond R&D and patents—it encompasses the strategic development of new products, processes, and business

JEL Classification — O31, G34

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models that enhance long-term performance (Amabile, 1988; Teece, 2007; Tidd & Bessant, 2020). Despite its significance, the evolution of innovation culture within firms and the governance mechanisms that support it remain underexplored.

This study pursues two main objectives: first, to investigate whether the culture of innovation among U.S. publicly traded firms has changed over time; and second, to examine whether board independence and gender diversity influence this temporal evolution. In addressing these goals, we evaluate competing hypotheses regarding the stability, growth, or decline of innovation culture, with particular focus on the “innovation surge” hypothesis—which suggests that innovation culture has intensified in response to rapid technological progress and heightened competitive pressures.

To empirically investigate these questions, we employ a novel text-based measure of innovation culture developed by Li *et al.* (2021), derived from machine learning analysis of earnings call transcripts. This approach allows us to quantify firms’ strategic emphasis on innovation in real time—capturing cultural aspects that are not visible through traditional metrics like patents or R&D spending. Our dataset spans 2001–2018 and includes over 50,000 firm-year observations, enabling a robust temporal analysis. We also incorporate a comprehensive set of control variables and employ fixed effects panel regressions to account for firm-specific unobservables.

Our findings confirm a statistically significant and positive temporal trend in corporate innovation culture, consistent with the view that firms have increasingly prioritized innovation. Furthermore, we find that board independence and gender diversity significantly amplify this trend over time. Independent directors, by promoting objective oversight and long-term strategic thinking, foster an environment conducive to innovation (Balsmeier, Fleming, & Manso, 2017; Lu & Wang, 2018). Similarly, gender-diverse boards contribute diverse perspectives that enhance problem-solving and creativity, reinforcing the firm’s cultural commitment to innovation (Díaz-García, González-Moreno, & Sáez-Martínez, 2013; Torchia, Calabrò, & Huse, 2011).

This study contributes to the literature in two key ways. First, we provide empirical validation of a rising innovation culture across firms, supported by a novel text-based method. Second, we highlight the pivotal role of board governance—particularly independence and diversity—in shaping and sustaining this cultural shift. These insights are directly relevant to corporate leaders and policymakers seeking to promote long-term innovation through board composition and governance reforms.

To provide a clear roadmap for the paper, we outline its structure as follows. Section 2 reviews prior research and develops the study’s hypotheses, examining different perspectives on the evolution of corporate innovation culture. Section 3 describes the data and methodology, including the construction of our text-based innovation measure, key variables, and econometric framework. Section 4 presents the empirical results, focusing on the temporal trends in innovation culture and the moderating effects of board independence and gender diversity. Finally, Section 5 summarizes the key findings of the study.

2. Literature review and hypothesis development

2.1 Literature review

To better understand the foundations of our analysis, we review prior studies on how innovation has been measured and the theoretical underpinnings of innovation culture.

Corporate innovation culture refers to the values, norms, and practices within an organization that foster continuous innovation, risk-taking, and technological advancement. It is shaped by various internal and external factors, including corporate governance, industry competition, financial resources, and regulatory environments. However, the formation of corporate innovation culture is not uniform across firms, as it depends on firm-specific characteristics such as leadership style, strategic vision, and financial constraints (O’Reilly & Tushman, 2013).

Corporate innovation culture is a fundamental driver of firm competitiveness, influencing the ability to develop new products, processes, and business models that contribute to long-

term success. An innovation-oriented culture enables firms to respond to market disruptions, adapt to technological advancements, and maintain a competitive edge in a rapidly evolving business environment (Amabile, 1988; Teece, 2007). Firms that successfully cultivate a strong innovation culture tend to outperform their peers in productivity, profitability, and overall market valuation. However, despite its recognized importance, measuring and quantifying corporate innovation culture remains a challenge.

Historically, corporate innovation has been assessed using patent counts, R&D expenditures, and citation-based metrics (Atanassov, 2013; Fang, Tian, & Tice, 2014; Griliches, 1998; Kogan, Papanikolaou, Seru, & Stoffman, 2017). While these indicators offer insights into firms' innovation outputs, they often fail to capture the cultural and strategic underpinnings that drive innovation. For instance, patent-based metrics reflect technological output but not the underlying intent or mindset that supports innovation (Kelly, Papanikolaou, Seru, & Taddy, 2021).

While much of the literature has relied on a small set of conventional indicators, there is a growing effort to broaden the measurement of innovation culture beyond these traditional metrics. Scholars now highlight the importance of structural and organizational inputs, such as R&D expenditures, human resources, and organizational capabilities, including the number of researchers, employees in STEM fields, and collaborations with research centers. They also point to cognitive, organizational, and technological outputs, such as patents, scientific publications, co-created knowledge, product or process launches, revenues from recent innovations, and the internal adoption of innovative solutions. In addition, composite indicators are increasingly emphasized as a way to capture broader cultural and organizational dynamics, including leadership commitment, openness to risk, knowledge diffusion, and overall attitudes toward innovation. Taken together, these perspectives reflect the recognition that innovation culture is not a single construct but rather a constellation of interrelated factors and organizational structures that jointly create an environment conducive to innovation and strengthen a firm's innovative capacity (OECD/Eurostat, 2018; Dziallas & Blind, 2019).

Furthermore, recent advances in machine learning and text-based analysis offer a more comprehensive approach to measuring corporate innovation culture. Li *et al.* (2021) introduce a novel methodology that analyzes textual data from earnings call transcripts to quantify firms' strategic emphasis on innovation. This text-based metric provides a more accurate measure of innovation culture, capturing not only firms' explicit innovation-related discussions but also the underlying sentiment and strategic intent conveyed in corporate communications. By leveraging large-scale textual analysis, researchers can assess how firms articulate their innovation strategies over time, providing deeper insights into how innovation culture evolves across different industries and governance structures.

This study builds upon prior work by employing a text-based approach to assess the long-term trends in corporate innovation culture. Unlike traditional measures, our approach allows us to analyze over 50,000 firm-year observations, capturing how firms' innovation language has shifted over nearly two decades. By integrating this novel metric with firm-level governance characteristics, we provide new insights into the role of board composition in shaping innovation culture, addressing gaps in the literature that focus primarily on patent-based indicators.

Building on these insights, the next section develops a set of hypotheses that reflect differing theoretical expectations regarding the direction and determinants of change in innovation culture.

2.2 Hypothesis development

To investigate the main factors that influence corporate innovation culture, we formulate five hypotheses that explore different perspectives on its temporal evolution and the role of board composition. These hypotheses are grounded in prior research and theoretical frameworks and are presented below.

2.2.1 The stability in innovation hypothesis. The evolution of corporate culture regarding innovation may not have seen significant changes due to the deeply embedded nature of organizational values and norms, which evolve slowly. [Griliches \(1998\)](#) suggests that while patent data shows fluctuations in innovation, the core inventive capabilities and cultural frameworks within firms remain consistent. Similarly, [Syverson \(2011\)](#) highlights the persistent differences in productivity across firms, attributing these to long-standing cultural and operational structures rather than rapid changes. [Kelly et al. \(2021\)](#) show that while there are technological waves, the underlying culture of innovation within firms remains stable over long periods.

H1. Corporate innovation culture remains largely unchanged over time due to the deeply embedded nature of organizational values and norms.

2.2.2 The innovation surge hypothesis. The cultural emphasis on innovation within corporations has significantly increased over the past few decades, primarily due to rapid technological advancements and competitive market pressures. [Alexopoulos \(2011\)](#) highlights the surge in technology-related publications as an indicator of this cultural shift, with businesses increasingly recognizing the importance of staying at the forefront of technological innovation to maintain a competitive edge. This is further supported by [Kogan et al. \(2017\)](#), who finds that the private economic value of patents has grown, reflecting heightened corporate investment in innovative activities. [Kelly et al. \(2021\)](#) reveal a substantial rise in the number of breakthrough patents, especially after 1980, indicating a robust cultural shift towards prioritizing innovation. [Fiordelisi, Renneboog, Ricci, and Lopes \(2019\)](#) show that a creative corporate culture, which fosters innovation, has become a critical driver of market value and patent output.

[Wilf \(2015\)](#) theorizes that institutionalized innovation in complex industrial societies drives cultural evolution, further suggesting a structured and deliberate focus on innovation within corporate environments. This trend is driven by the need for businesses to continually adapt to fast-paced technological changes and the pressures of globalization, which have made innovation a key component of corporate strategy. Companies have increasingly adopted practices such as agile methodologies, open innovation platforms, and collaborative partnerships to foster a culture that encourages creativity and the development of new ideas. These efforts are evident in the increased patent activity and higher market valuation of innovative firms, suggesting a strong and growing culture of innovation across various industries.

H2. Corporate innovation culture has strengthened over time, driven by rapid technological advancements and competitive market pressures.

2.2.3 The innovation decline hypothesis. Despite the overall trend towards greater innovation, some studies suggest that the corporate culture of innovation has declined in certain contexts due to increasing bureaucratic constraints and a focus on short-term financial performance. [Gordon \(2017\)](#) points to a noticeable slowdown in productivity growth in recent decades, suggesting that the innovative capacity of firms may be waning. [Syverson \(2011\)](#) highlights persistent productivity differences across firms, indicating that some organizations may have become more risk-averse and less inclined to invest in long-term innovative projects. [Kelly et al. \(2021\)](#) identify periods of stagnation in technological innovation, particularly before the resurgence in the post-1980 period, highlighting the challenges of maintaining a dynamic innovation culture. [Olori and Mark \(2013\)](#) emphasize that certain constructs of organizational culture can serve as significant impediments to innovation, particularly in environments that prioritize efficiency and cost-cutting over creative endeavors.

Additionally, the rise of monopolistic practices and industry consolidation has reduced competitive pressures, leading some firms to deprioritize innovation. This conservative approach is reflected in reduced patent activity and a lower market valuation for firms that fail to innovate, indicating that while some sectors may thrive in an innovation-driven culture,

others may lag behind due to these constraints (Aghion, Bloom, Blundell, Griffith, & Howitt, 2005; Autor, Dorn, Katz, Patterson, & Van Reenen, 2020).

H3. Corporate innovation culture has weakened due to bureaucratic constraints, risk aversion, and a focus on short-term financial performance.

2.2.4 The moderating roles of board independence and board gender diversity. Board independence plays a crucial role in shaping the trajectory of corporate culture, particularly in fostering or hindering innovation. Independent directors are often seen as effective monitors of managerial behavior due to their lack of ties to the company, allowing them to make unbiased decisions that can drive long-term innovation. Conyon and Peck (1998) argue that boards with a higher proportion of independent directors are more effective in aligning management actions with shareholder interests, potentially accelerating the adoption of innovative practices. However, independent directors may also slow down the pace of innovation by imposing stringent oversight and risk-averse policies, as highlighted by Finkelstein, Hambrick, and Cannella (1996), who suggest that independent directors might focus on stability and risk mitigation, which could inhibit radical innovation initiatives. Thus, while board independence can enhance the quality of decision-making and promote sustainable innovation, it may also temper the speed at which innovative changes are implemented.

H4. Greater board independence strengthens corporate innovation culture over time.

The inclusion of women on corporate boards can significantly influence the evolution of a company's culture of innovation. Gender diversity brings diverse perspectives and problem-solving approaches, which can enhance creativity and innovation. Adams and Ferreira (2009) find that gender-diverse boards are more likely to engage in rigorous monitoring, leading to better decision-making and innovative outcomes. Women directors are also more likely to advocate for inclusive and progressive policies that foster a culture of innovation. However, the mere presence of women on boards does not automatically translate to increased innovation. If gender diversity is not coupled with genuine empowerment and participation in strategic decisions, it might lead to tokenism without substantial impact on innovation culture. Moreover, Lucas-Pérez, Mínguez-Vera, Baixauli-Soler, Martín-Ugedo, and Sánchez-Marín (2015) suggest that while gender diversity can enhance board effectiveness, it might also introduce conflicts and slower decision-making processes, potentially delaying the implementation of innovative strategies. Therefore, board gender diversity can either accelerate or slow down the rise of corporate innovation depending on how well it is integrated into the board's functioning.

H5. Higher board gender diversity positively influences corporate innovation culture over time.

3. Methodology

Our study employs an explanatory quantitative research approach to investigate the temporal evolution of corporate innovation culture and the moderating role of board composition. We apply regression modeling with firm fixed effects to identify patterns and causal relationships in corporate innovation culture over time. Our methodological perspective is rooted in empirical corporate finance, leveraging text-based machine learning techniques (Li *et al.*, 2021) to quantify firms' innovation culture from earnings call transcripts. This approach allows for a systematic and objective measurement of innovation culture.

3.1 Sample selection

We start with the initial dataset provided by Li *et al.* (2021), which contains a text-based metric for corporate culture of innovation. We augment this dataset with additional firm-specific

characteristics and financial statement information obtained from COMPUSTAT. Information on board characteristics, such as board independence and gender diversity, is sourced from Institutional Shareholder Services (ISS).

We focus on U.S. firms since the text-based data from [Li et al. \(2021\)](#) is only available for U.S. companies. The five largest industries in our sample are business services, chemicals and allied products, electronic and electrical equipment, instruments and related products, and industrial and commercial machinery, reflecting a diverse representation of sectors engaged in innovation. Our final dataset is an unbalanced panel consisting of 51,533 firm-year observations spanning from 2001 to 2018, as this is the period for which the text-based innovation culture data is available. Even if additional data existed beyond this timeframe, extending the sample further would not be advisable, as the COVID-19 pandemic introduced significant disruptions that could distort the measurement of innovation culture and its trends. To our knowledge, this sample is the most extensive available in the current literature on this topic.

3.2 *Measuring corporate culture of innovation through textual analysis*

In their groundbreaking study, [Li et al. \(2021\)](#) introduce a novel technique for evaluating corporate culture by leveraging advanced machine learning to analyze textual data from earnings call transcripts. Their approach identifies five core corporate values—innovation, integrity, quality, respect, and teamwork—and systematically quantifies firms’ emphasis on each. While their study provides a broad measure of corporate culture, our research specifically focuses on the corporate innovation culture component, which we use as the dependent variable in our analysis to examine its evolution over time.

[Li et al. \(2021\)](#) employ natural language processing (NLP) algorithms to extract relevant phrases from a large dataset of earnings call transcripts, filtering out irrelevant content to focus on expressions that genuinely reflect corporate innovation, such as creativity, technological progress, and strategic initiatives. Their methodology ensures a high degree of precision and reliability in capturing the nuances of corporate discourse. To validate their index, they conduct extensive robustness tests, comparing it against external innovation measures and assessing its predictive power in explaining corporate behaviors, financial performance, and competitive advantage. By systematically quantifying innovation-related language, they construct a comprehensive corporate innovation index that provides a reliable and objective measure of firms’ innovation culture.

One of the key strengths of the corporate innovation culture score is its complexity and comprehensiveness, as it captures a firm’s strategic emphasis on innovation beyond traditional innovation proxies such as patent counts and R&D expenditures. Unlike these conventional measures, which focus on tangible innovation outputs, the text-based innovation index reflects how firms articulate and communicate their innovation strategies in real time. To provide greater clarity on its quantitative nature, our study includes a descriptive analysis of its scale and variation, offering deeper insights into how firms’ innovation culture differs across firms and evolves over time. By adopting this advanced text-based metric, our research enhances the understanding of corporate innovation culture, highlighting its dynamic interactions with governance and financial characteristics.

3.3 *Empirical modeling*

Basically, we estimate the following regression analysis.

$$\text{Corporate Innovation}_{it} = \alpha + \beta_1(\text{Time Trend})_t + \beta_2(\text{Controls})_{it} + \text{Firm Fixed Effects}_i + \epsilon_{it}$$

In this panel model with firm fixed effects, *i* indexes firms and *t* indexes years. The primary focus of our empirical model is to capture the temporal evolution of corporate innovation

culture. The time trend variable increases by one for each passing year. By including a vector of control variables, we account for various firm-specific characteristics that may influence a firm's ability to innovate. These control variables ensure that our analysis considers differences in financial health, resource availability, and strategic priorities across firms. Firm fixed effects account for unobserved heterogeneity across firms, such as intrinsic corporate values or industry-specific factors that remain constant over time. Including fixed effects in the model is essential, as it helps reduce omitted variable bias, mitigates an important source of endogeneity, and yields more consistent coefficient estimates, thereby avoiding interpretation errors [1].

To account for factors that may affect corporate innovation, we incorporate a comprehensive set of control variables from prior research (Atanassov, 2013; Fang *et al.*, 2014; Ongsakul, Chatjuthamard, & Jiraporn, 2022, 2024). These include firm size (log of total assets), profitability (EBIT/total assets), leverage (total debt/total assets), capital expenditures (capital expenditures/total assets), R&D investments (R&D/total assets), advertising intensity (advertising expense/total assets), dividend distributions (dividends/total assets), asset tangibility (fixed assets/total assets), discretionary spending (SG&A expense/total assets), and liquidity (current assets/current liabilities). Definitions for these variables are provided in Table A1 in the Appendix, and their summary statistics are presented in Table 1. The correlation matrix is shown in Table A2 in the Appendix [2].

Firm size is expected to have a positive or ambiguous relationship with corporate innovation culture. Larger firms typically possess greater financial and organizational resources to support innovation initiatives, but they may also suffer from bureaucratic inertia that stifles agility and creativity. Profitability is generally expected to have a positive effect. Profitable firms face fewer financial constraints and are better positioned to fund long-term strategic initiatives, including those that foster a strong innovation culture. Leverage is anticipated to show a negative relationship. Highly leveraged firms are often more risk-averse due to debt obligations, making them less likely to invest in uncertain and long-term innovation projects.

Table 1. Descriptive statistics

Variable	Mean	SD	25 th	Median	75 th
<i>Corporate innovation</i>					
Corporate Innovation	1.864	1.180	1.031	1.583	2.403
<i>Firm-specific characteristics</i>					
Firm Size	6.895	2.067	5.460	6.832	8.256
Profitability	0.019	0.202	0.006	0.063	0.111
Total Debt	0.247	0.231	0.030	0.212	0.378
Capital Investments	0.051	0.057	0.015	0.032	0.063
R&D Intensity	0.054	0.108	0.000	0.001	0.062
Advertising Intensity	0.011	0.028	0.000	0.000	0.006
Cash Holdings	0.205	0.226	0.038	0.115	0.295
Dividends	0.014	0.031	0.000	0.000	0.017
Fixed Assets	0.507	0.424	0.167	0.382	0.781
Current Ratio	2.542	2.441	1.165	1.824	2.966
<i>Board attributes</i>					
% Independent Directors	77.145	12.932	70.000	80.000	87.500
% Female Directors	13.277	10.547	0.000	12.500	20.000
Ln (Board Size)	2.293	0.214	2.197	2.303	2.398

Note(s): This table presents the summary statistics for the variables. The variable definitions are shown in Table A1 in the Appendix

The effect of capital expenditures is ambiguous. While such investments may reflect a firm's commitment to growth, they often target tangible assets rather than innovation-related intangibles, and may divert resources away from R&D and other innovation-supporting activities. R&D investments are expected to have a positive effect. They directly reflect a firm's commitment to innovation and signal a culture that values experimentation, technological advancement, and long-term competitiveness. Advertising intensity likely has a positive sign, particularly in sectors where innovation is closely tied to brand development and customer engagement. It may indicate a proactive and outward-facing innovation strategy.

Cash holdings are expected to have a positive effect on innovation culture. Firms with greater liquidity can more easily invest in risky and long-term innovation projects without relying on external financing. This financial flexibility supports experimentation, strategic agility, and resilience—key elements of an innovation-supportive environment. Dividend distributions may have a mixed effect. On one hand, they signal financial stability, which can support innovation. On the other hand, high payouts may limit internal funds available for investing in innovation, especially in the absence of external financing. Asset tangibility is expected to have a negative or neutral effect.

Firms with more tangible assets may be in traditional industries where innovation is less emphasized, whereas innovation-oriented firms often rely on intangible assets like intellectual property. Discretionary spending, as measured by SG&A, could have a positive association with innovation culture if it reflects investments in human capital, strategy, and marketing. However, excessive overhead may also indicate inefficiency. Liquidity is generally expected to have a positive impact. Firms with higher liquidity can more easily fund uncertain innovation efforts without relying on external capital, enabling greater flexibility and risk-taking.

In addition to the main variables discussed above, we include two board characteristics—board gender diversity and board independence—as key moderating variables. While not expected to have a direct effect on innovation culture, these variables are central to our analysis as they may shape how innovation culture evolves over time. Specifically, we examine whether these governance features amplify or dampen the temporal trend in innovation culture through interaction terms in the regression models.

Standard errors are clustered at the firm level. Clustering standard errors by firm is crucial in this analysis because it accounts for within-firm correlation over time, ensuring that statistical inferences are valid and robust. Since corporate innovation culture is measured across multiple years for the same firms, observations within a firm are likely to be correlated rather than independent. Ignoring this correlation could lead to underestimated standard errors, artificially inflating the significance of regression coefficients.

4. Results

The results in Table 2 show significant and positive coefficients for the time trend (0.063 in Model 1 and 0.061 in Model 2), indicating a steady increase in the corporate culture of innovation over the examined period. This finding provides strong support for the innovation surge hypothesis, which posits that the cultural emphasis on innovation within corporations has intensified in response to rapid technological advances and heightened competitive pressures. In other words, firms have increasingly embraced innovation as a strategic priority, recognizing that staying at the forefront of technological development is essential for maintaining a competitive edge. These results align with the view that innovation culture has strengthened over time (Alexopoulos, 2011; Kelly *et al.*, 2021) and echo prior studies showing how firms adapt their orientation to meet technological change and competitive challenges (Fiordelisi *et al.*, 2019; Kogan *et al.*, 2017). Accordingly, the innovation surge hypothesis (H2) is supported, whereas the stability (H1) and decline (H3) hypotheses are not.

To ensure the robustness of our results, we employ Oster's (2019) methodology. Oster's approach for assessing coefficient stability examines the impact of omitted variable bias on the

Table 2. Temporal dynamics of corporate culture of innovation

	(1) Culture of innovation	(2) Culture of innovation
<i>Time Trend</i>	0.063*** (38.120)	0.061*** (31.034)
Firm Size		0.032* (1.929)
Profitability		−0.012 (−0.234)
Total Debt		−0.053 (−1.258)
Capital Investments		0.009 (0.074)
R&D Intensity		0.301** (2.106)
Advertising Intensity		0.636 (1.076)
Cash Holdings		0.132* (1.948)
Dividends		0.458** (2.104)
Fixed Assets		−0.005 (−0.140)
Current Ratio		0.003 (0.721)
Constant	1.223*** (72.596)	0.969*** (8.472)
Firm Fixed Effects	Yes	Yes
Observations	50,890	50,890
Adjusted R-squared	0.600	0.600

Note(s): Robust *t*-statistics in parentheses****p* < 0.01, ***p* < 0.05, **p* < 0.1This table presents the regression results. The variable definitions are shown in [Table A1](#) in the [Appendix](#)

estimated coefficients. This method involves comparing the coefficient estimates and R-squared values from a model with control variables to those from a model without them. This comparison provides an adjusted estimate that accounts for potential omitted variable bias, offering a more accurate measure of the stability and robustness of the estimated effects. A significant advantage of [Oster's \(2019\)](#) technique is its systematic evaluation of bias from omitted variables. Traditional methods often overlook the influence of unobserved factors, but Oster's approach explicitly addresses this, providing a more thorough analysis.

We apply [Oster's \(2019\)](#) method to the time trend coefficient in Model 2 of [Table 2](#). Our analysis indicates that the threshold for the effect of unobservables required to invalidate our results is 2.00. In other words, the effect of unobservables would have to be twice as strong as that of observables to nullify our results. This high threshold suggests a strong confidence level in the stability and minimal bias of our estimated coefficients. It indicates that our results are robust to a considerable amount of potential bias, thereby reinforcing the credibility of our findings.

In addition, it is estimated that, To invalidate our findings, 93.22% of the estimated effect would have to be attributed to bias. This means that nearly all of the observed effect would need to be due to some form of bias or omitted variables for our conclusions to be incorrect. In practical terms, out of our dataset of 51,533 firm-year observations, 93.22% (or 48,039) would need to be replaced with cases where there is no effect on innovation culture. This high

threshold indicates a very low likelihood that our results are invalid. It suggests that our findings are robust and that the observed positive trend in innovation culture is genuine and not merely a result of unobserved biases.

Table 3 explores the moderating roles of board independence and gender diversity on the culture of innovation within firms. The interaction term between the time trend and the percentage of independent directors ($\text{Time Trend} \times \% \text{Independent Directors}$) in Model 1 is positive and significant, indicating that the presence of independent directors amplifies the positive trend in innovation culture over time. This finding supports the innovation surge hypothesis, which posits that the cultural emphasis on innovation has increased due to the

Table 3. The moderating roles of board independence and board gender diversity

	(1) Culture of innovation	(2) Culture of innovation
<i>Time Trend $\times$ % Independent Directors</i>	0.0005** (2.3597)	
<i>Time Trend $\times$ % Female Directors</i>		0.0015*** (5.8774)
% Independent Directors	−0.0041** (−2.5668)	−0.0004 (−0.3514)
% Female Directors	0.0017 (1.0257)	−0.0149*** (−4.8466)
Ln (Board Size)	0.1017 (1.3598)	0.1449* (1.9458)
Time Trend	0.0344** (2.1201)	0.0488*** (8.9257)
Firm Size	0.0210 (0.5598)	0.0362 (0.9529)
Profitability	0.1329 (1.0276)	0.1085 (0.8333)
Total Debt	0.0131 (0.1355)	−0.0189 (−0.1968)
Capital Investments	−0.6684*** (−2.7157)	−0.6724*** (−2.7760)
R&D Intensity	0.5229 (0.9071)	0.6581 (1.1495)
Advertising Intensity	0.4053 (0.3434)	0.3489 (0.3036)
Cash Holdings	0.1766 (1.1770)	0.1862 (1.2578)
Dividends	1.0918** (1.9734)	0.9912* (1.8417)
Fixed Assets	0.0045 (0.0487)	0.0224 (0.2431)
Current Ratio	−0.0075 (−0.7087)	−0.0088 (−0.8353)
Constant	1.0858*** (3.0710)	0.8057** (2.3582)
Firm Fixed Effects	Yes	Yes
Observations	16,733	16,733
Adjusted R-squared	0.6693	0.6716

Note(s): Robust *t*-statistics in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

This table presents the regression results with interactions with board composition. The variable definitions are shown in Table A1 in the Appendix

proactive roles played by independent directors in fostering innovative practices. Independent directors, with their objective stance and diverse perspectives, likely encourage risk-taking and long-term strategic planning, which are essential for innovation.

Conversely, the direct effect of the percentage of independent directors on the culture of innovation is negative and significant in the initial model but turns positive and significant when interacted with the time trend. This pattern suggests that while independent directors may initially appear to constrain innovative activity, not only because of conservative oversight but also because they require time to develop firm-specific and industry-specific knowledge, their long-term influence ultimately strengthens a culture of innovation as they gain experience and strategically shape innovation-related decisions. This result reflects the complexity described by previous research, which argues that independent directors might balance between stability and innovation.

The interaction term between the time trend and the percentage of female directors (Time Trend $\times$ % Female Directors) in Model 2 is also highly significant, demonstrating that gender diversity on boards contributes positively to the innovation culture over time. This finding bolsters the innovation surge hypothesis, suggesting that diverse boards bring varied perspectives and problem-solving approaches, enhancing creativity and innovation. Studies have corroborated this by showing how gender diversity can lead to better decision-making and more innovative outcomes. However, the direct effect of the percentage of female directors on innovation culture is negative and significant in the final model, indicating that without the dynamic element of time, gender diversity alone may not suffice to drive innovation, possibly due to initial integration challenges and tokenism issues.

In summary, the findings from Table 3 suggest that both independent directors and gender-diverse boards significantly contribute to enhancing the culture of innovation over time (H4 and H5 are supported). This evidence supports the innovation surge hypothesis, demonstrating that sustained efforts to diversify board composition and include independent directors are effective strategies for fostering a robust culture of innovation in firms. These insights are crucial for corporate governance policies aimed at promoting long-term innovative capacities within organizations.

These findings extend prior research on board governance (Balsmeier *et al.*, 2017; Conyon & Peck, 1998), illustrating how independent and gender-diverse boards foster conditions that sustain innovation culture over time. This builds on the literature discussed in Section 2 by showing that board structures are not just formalities but active drivers of cultural evolution.

The results in Table 4 illustrate the interactions between the time trend and various firm-specific characteristics in relation to the culture of innovation. The analysis in Table 4 is important because it examines how firm-specific financial characteristics—such as profitability, cash holdings, debt levels, and dividends—interact with the evolution of corporate innovation culture. While prior research has established that financial constraints and resource availability play a crucial role in shaping firms' ability to innovate (Aghion *et al.*, 2005; Kogan *et al.*, 2017), few studies have explored how these factors influence the broader cultural dimensions of innovation over time. Firms with strong financial health may have more flexibility to allocate resources toward long-term innovation strategies, while those with higher financial constraints may be forced to prioritize short-term stability over risk-taking and experimentation (Autor *et al.*, 2020; Fiordelisi *et al.*, 2019). Examining these interactions provides a more comprehensive understanding of how financial stability and strategic resource allocation contribute to the sustainability of an innovation-oriented culture. This analysis extends the literature by integrating firm-specific financial conditions with the study of innovation culture, offering new insights into the conditions that enable or hinder firms from fostering a sustained commitment to innovation.

First, profitability is an important characteristic because it reflects the financial health and resource availability of a firm to invest in innovative projects. The interaction term between the time trend and profitability (Time Trend $\times$ Profitability) is positive and highly significant ($p < 0.01$). This suggests that profitable firms are more likely to enhance their innovation

Table 4. Interactions with firm-specific characteristics

	(1) Culture of innovation	(2) Culture of innovation	(3) Culture of innovation	(4) Culture of innovation
<i>Time Trend × Profitability</i>	0.051*** (4.909)			
<i>Time Trend × Cash Holdings</i>		0.006 (0.758)		
<i>Time Trend × Total Debt</i>			−0.016** (−2.399)	
<i>Time Trend × Dividends</i>				0.114** (2.476)
Time Trend	0.060*** (29.544)	0.060*** (26.241)	0.065*** (23.770)	0.059*** (28.788)
Firm Size	0.018 (1.118)	0.032* (1.943)	0.031* (1.873)	0.033** (2.008)
Profitability	−0.522*** (−4.548)	−0.015 (−0.284)	−0.010 (−0.193)	−0.014 (−0.270)
Total Debt	−0.037 (−0.867)	−0.053 (−1.259)	0.116 (1.489)	−0.057 (−1.370)
Capital Investments	0.000 (0.001)	0.012 (0.091)	0.012 (0.094)	0.005 (0.040)
R&D Intensity	0.254* (1.795)	0.301** (2.101)	0.295** (2.063)	0.300** (2.102)
Advertising Intensity	0.660 (1.112)	0.622 (1.051)	0.596 (1.010)	0.646 (1.094)
Cash Holdings	0.122* (1.812)	0.075 (0.767)	0.143** (2.122)	0.130* (1.921)
Dividends	0.372* (1.717)	0.449** (2.067)	0.435** (1.999)	−0.710 (−1.455)
Fixed Assets	−0.006 (−0.147)	−0.004 (−0.109)	−0.004 (−0.104)	−0.001 (−0.022)
Current Ratio	0.001 (0.182)	0.003 (0.787)	0.003 (0.698)	0.003 (0.669)
Constant	1.088*** (9.488)	0.976*** (8.594)	0.932*** (8.007)	0.977*** (8.529)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	50,890	50,890	50,890	50,890
Adjusted R-squared	0.601	0.600	0.600	0.600

Note(s): Robust *t*-statistics in parentheses

****p* < 0.01, ***p* < 0.05, **p* < 0.1

This table presents the regression results with interactions with firm-specific characteristics. The variable definitions are shown in [Table A1](#) in the [Appendix](#)

culture over time, supporting the notion that financial resources are critical for sustaining long-term innovation activities. This aligns with the innovation surge hypothesis, where firms under competitive pressures and possessing ample resources are better positioned to prioritize and invest in innovation.

Cash holdings are another key characteristic, representing liquidity and the ability to fund immediate innovation activities without relying on external financing. The interaction between the time trend and cash holdings (*Time Trend × Cash Holdings*) is positive but not statistically significant. This indicates that while liquidity might be beneficial, it does not have a strong incremental effect on fostering innovation culture over time. This result might suggest that simply having cash on hand is not sufficient; strategic allocation and effective use of these resources are critical.

Total debt, which indicates the level of financial leverage, has a significant negative interaction with the time trend (Time Trend $\times$ Total Debt, $p < 0.05$). This finding suggests that higher levels of debt might constrain a firm's ability to innovate by imposing financial stress and reducing flexibility in investing in long-term innovative projects. This supports the innovation decline hypothesis, highlighting that financial constraints and risk aversion due to debt can hinder the development of an innovation-oriented culture.

Dividends, representing the firm's commitment to returning profits to shareholders, show a positive and significant interaction with the time trend (Time Trend $\times$ Dividends, $p < 0.05$). This result indicates that firms with a consistent dividend payout are likely to foster a stronger innovation culture over time. This could be because such firms are generally financially stable and can balance rewarding shareholders while still investing in innovation. It also suggests that maintaining shareholder trust and satisfaction can provide a supportive environment for innovative initiatives.

In conclusion, the results from Table 4 reveal that firm-specific characteristics like profitability, cash holdings, total debt, and dividends play significant roles in shaping the culture of innovation over time. Profitable and dividend-paying firms are more likely to cultivate an innovative culture, while high debt levels can pose a significant barrier. These findings emphasize the importance of strategic financial management in fostering a sustainable culture of innovation within firms.

Our results echo concerns raised by Gordon (2017) and Syverson (2011) about the dampening effects of financial constraints on innovation. The significant positive interaction with profitability supports the idea that resource-rich firms are better able to maintain a long-term innovation culture, consistent with Aghion *et al.* (2005).

5. Conclusions

We investigate the temporal dynamics of corporate culture of innovation and the influence of firm-specific characteristics, with particular attention to board independence and gender diversity. Our findings provide significant insights into how these factors shape the culture of innovation over time, contributing to the broader literature on corporate governance and innovation management.

The results demonstrate a consistent and positive trend in the culture of innovation over the studied period, supporting the innovation surge hypothesis. Firms have increasingly embraced a culture of innovation, driven by rapid technological advancements and competitive market pressures. This sustained growth in innovation culture is essential for maintaining a competitive edge in today's fast-paced market environment.

Our analysis reveals the significant moderating roles of board independence and board gender diversity. Independent directors amplify the positive trend in innovation culture, as their objective perspectives encourage risk-taking and long-term strategic planning, which are vital for fostering innovation. Similarly, gender-diverse boards positively contribute to innovation culture over time. These findings underline the importance of board composition in enhancing a firm's innovative capabilities, providing valuable insights for corporate governance policies aimed at promoting diversity and independence on boards.

Overall, our findings emphasize the importance of strategic financial management and diverse, independent board compositions in fostering a sustainable culture of innovation within firms. These insights contribute to the literature by providing empirical evidence on the dynamic interactions between corporate governance, firm-specific characteristics, and innovation culture over time. They highlight the critical role of long-term strategic planning and resource allocation in enhancing a firm's innovative capabilities, offering practical implications for policymakers and corporate leaders aiming to promote innovation-driven growth.

While this study offers key insights into the evolution of corporate innovation culture and the roles of board independence and gender diversity, some limitations remain. Our reliance on

a text-based innovation measure from earnings call transcripts captures firms' strategic articulation of innovation but may not fully reflect actual innovation outcomes. Future research could incorporate alternative indicators such as, product launches, or third-party innovation assessments to enhance robustness. Additionally, while we observe a positive long-term trend in corporate innovation culture, further studies could assess whether this trend is sustainable amid economic shifts, regulatory changes, or technological disruptions.

Our analysis is also limited to publicly traded U.S. firms, restricting the generalizability of findings to firms in other institutional settings. Corporate governance structures and innovation incentives may vary across international markets or private firms, warranting further investigation. Expanding the dataset to include emerging markets or privately held companies could provide deeper insights into how different governance environments shape innovation culture. By addressing these limitations, future research can offer a more comprehensive perspective on corporate innovation dynamics across diverse business landscapes.

Notes

1. The Hausman test shows that fixed effects are more appropriate, as they better account for hidden differences across firms and lead to more trustworthy results.
2. We calculate the Variance Inflation Factors (VIFs) to assess multicollinearity among the independent variables. All VIF values are well below the commonly used threshold of 10, indicating that multicollinearity is not a concern.

Supplementary material

The supplementary material for this article can be found online.

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