Navigating Competitor Networks:
The Influence of Geographic Density on Corporate Governance

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Abstract

This study examines the impact of geographic density on corporate governance, focusing on board characteristics and CEO compensation in U.S. publicly listed firms. Using a novel measure of geographic density, our analysis reveals that firms within dense competitive networks tend to have smaller, more independent boards, and attract executives with diverse educational backgrounds and extensive professional networks. Additionally, geographic density is associated with higher CEO compensation, emphasizing the strategic importance of competitive environments in shaping governance practices. These findings suggest that geographic density enhances board effectiveness and strategic decision-making, offering insights into how firms can leverage competitive networks to improve governance outcomes. A subsample analysis of selected states reveals regional variations, demonstrating that the effects of geographic density can differ by location, thereby offering a deeper understanding of geographic context in corporate governance.

Keywords: *geographic density, corporate governance, CEO compensation*

1. Introduction

The concept of agglomeration economies provides a foundational framework for understanding the strategic advantages firms derive from geographic clustering. Originally introduced by Marshall (1920), agglomeration economies refer to the benefits that firms accrue by locating in close proximity to each other. These benefits include shared access to specialized labor markets, knowledge spillovers, and reduced transaction costs. In such environments, firms are not only exposed to competitive pressures but also benefit from an enriched atmosphere that fosters collaboration, innovation, and information exchange.

The strategic value of proximity is particularly pronounced in the context of corporate governance, where board members and executives can leverage local networks to enhance decision-making and oversight functions. One of the primary mechanisms through which agglomeration economies exert their influence is by enhancing the flow of information. In dense competive network, firms can access industry-specific knowledge more readily, enabling them to stay abreast of market trends, technological advancements, and competitive strategies. This enhanced information flow is particularly valuable for board members, who are tasked with overseeing firm strategy and governance. Proximity to competitors facilitates informal interactions and formal collaborations, leading to more effective communication channels and a richer pool of insights that can be leveraged for strategic decision-making.

The reduction in information acquisition costs is a significant advantage for firms situated in agglomerated environments. Alam et al. (2014) highlight that directors who are geographically closer to their serving boards incur lower costs in acquiring and processing firm-specific information. This proximity allows for more frequent face-to-face interactions, which are instrumental in building trust and facilitating the exchange of complex, nuanced information. As a result, board members can make more informed decisions, contributing to enhanced governance and oversight. Geographic proximity profoundly influences board characteristics, including size, independence, and diversity. Firms located within dense networks of competitors often have smaller boards, as the ease of accessing local insights and expertise reduces the necessity for larger boards traditionally required to cover a wide array of informational needs. Smaller boards benefit from streamlined communication and decision-making processes, allowing for more agile responses to market changes. Geographic proximity also plays a critical role in enhancing board independence. Firms situated near their competitors are more likely to be exposed to a wider spectrum of independent industry practices and benchmarks. This exposure fosters a governance culture that benefits from a comprehensive array of external viewpoints, rather than being solely reliant on internal management. The proximity to a network of competitors cultivates an environment where board decisions are influenced by a diverse set of independent insights, thereby reinforcing the board's autonomy and ability to oversee management practices effectively.

Furthermore, geographic clustering fosters diversity by facilitating access to a broader pool of talent with varied backgrounds and expertise. Dense competitor networks increase the availability of skilled professionals, allowing firms to enrich their boards with diverse perspectives that drive innovation and strategic foresight. This diversity is crucial for fostering independent thought and mitigating groupthink, ultimately enhancing the board's effectiveness in navigating complex business landscapes. The influence of geographic proximity extends beyond board characteristics to encompass CEO compensation structures. The competitive dynamics of agglomerated environments necessitate attractive compensation packages to attract and retain top executive talent. Firms in these clusters are compelled to offer premium compensation to secure leaders capable of navigating the challenges and opportunities presented by dense networks. Geographic proximity correlates with higher levels of CEO compensation, reflecting the premium placed on acquiring talent with the expertise required to excel in competitive settings. The growth trajectory of CEO compensation is similarly affected by geographic density, as executives in these environments benefit from accelerated learning and expanded professional networks, enhancing their ability to drive superior firm performance.

Additionally, the composition of CEO compensation packages, including bonuses, stock options, and performance incentives, is shaped by the need to align executive interests with long-term strategic goals. In dense networks, compensation structures are often more complex and performance-driven, reflecting the nuanced challenges and opportunities presented by the

competitive landscape. The theoretical framework further considers the role of competitive pressure in shaping governance practices and executive compensation. In densely populated clusters, firms are continuously benchmarked against one another, driving them to adopt best practices in governance and compensation. This competitive scrutiny discourages practices that could lead to conflicts of interest, such as the dual role of CEO and board chair, and promotes the inclusion of external directors who bring independent perspectives to the boardroom.

Knyazeva et al. (2013) suggest that the supply of directors in such environments bolsters board independence, as the increased availability of skilled professionals enriches the board's diversity in terms of viewpoints and expertise. This diversity is crucial for fostering independent thought and decision-making among board members, contributing significantly to overall governance quality. This theoretical framework establishes the foundational concepts that underpin the study of geographic proximity's impact on corporate governance and executive compensation. By integrating insights from agglomeration economies and emphasizing the role of information flow, board characteristics, and competitive pressure, this framework provides a comprehensive basis for exploring the strategic advantages firms derive from operating within dense competitor networks. The subsequent empirical analysis will build on this foundation to quantify the effects of proximity on board and CEO attributes, offering new perspectives on the interplay between geography and corporate strategy.

In addition to analyzing the full sample across the United States, this study conducts a subsample analysis focusing on California, New York, and Texas. These states are characterized by a high concentration of high-tech firms and serve as major hubs for business innovation and technological advancement. This subsample analysis aims to explore how geographic density within these key states influences board and CEO characteristics, shedding light on the unique dynamics at play in these pivotal markets. By examining these specific states, the research provides deeper insights into how geographic density affect corporate governance and compensation structures.

This study employs a comprehensive methodological framework to explore the impact of geographic density on corporate governance, specifically focusing on board characteristics and CEO compensation. The analysis utilizes a dataset comprising U.S. publicly listed firms from 1997 to 2019, sourced from Compustat, BoardEx, and the Text-based Network Industry Classifications (TNIC) dataset. The TNIC dataset, developed by Hoberg and Phillips, utilizes sophisticated text-parsing algorithms to identify product market competitors based on the similarity of firms' 10-K product descriptions. This allows for a dynamic and precise classification of competitive interactions, capturing the temporal and spatial aspects of competitive relationships. The primary dataset is constructed by merging firm-level financial data from Compustat with board and CEO data from BoardEx, alongside industry classification data from the TNIC dataset. BoardEx provides detailed information on board composition and

executive profiles, enabling an in-depth analysis of governance structures and compensation. The sample includes firms that are publicly traded on major U.S. stock exchanges, ensuring representativeness across the broader market.

Geographic density is measured using the concept of weighted strength, which captures the density of a firm's competitor network. This measure accounts for both the number of competitors and the strength of each connection, providing a comprehensive reflection of a firm's geographic competitive network. The weighted strength metric is derived from the geographic distance between a focal firm's headquarters and those of its competitors, as identified by the TNIC dataset, and takes into account the firm's spatial positioning within a competitive network. The analysis focuses on key board characteristics, including board size, independence, executive educational background, and professional networks, as well as CEO compensation structures. Board size is measured by the total number of directors, while independence is quantified by the proportion of independent directors on the board. The educational background of executives is assessed to determine the level of expertise and diversity in educational qualifications present within the board, reflecting a variety of perspectives available for strategic decision-making. Professional networks of executives are analyzed to understand the extent of their external connections and influence, which may contribute to board effectiveness and decision-making quality. CEO compensation is analyzed using data on total compensation, including salary, bonuses, stock options, and other incentives.

The study examines the level and growth of CEO compensation, as well as the structure of compensation packages, to understand how geographic density influences executive remuneration.

The empirical strategy employs a fixed-effects regression model to control for unobserved heterogeneity and isolate the effects of geographic density on the variables of interest. The fixed-effects model accounts for industry- and year-specific characteristics that may influence board and CEO dynamics, thereby providing a robust estimation framework for assessing the impact of geographic density.

This study makes significant contributions to the literature on corporate governance and strategic management by advancing the understanding of how geographic density influences board characteristics and CEO compensation. By leveraging the TNIC dataset, the study offers a dynamic and precise classification of competitive interactions, capturing the temporal and spatial dimensions of geographic density. This research highlights the strategic benefits of operating within geographic competitive networks, offering new insights into the interplay between geography and corporate governance. One of the key contributions is the demonstration of how geographic clustering enhances board independence and diversity, as well as influences board size. Our findings indicate that firms situated within dense geographic competitive networks tend to have smaller and more independent boards. This suggests that firms can leverage geographic density to achieve efficient board structures, thereby enhancing

decision-making and governance outcomes. The study also explores the impact of geographic density on executive educational background and professional networks. We find that firms in densely clustered environments attract executives with more diverse educational backgrounds and extensive professional networks. This diversity enriches the board's perspective, enabling better strategic oversight and innovation. Additionally, the research shows that geographic density positively affects CEO compensation, with firms in close proximity to competitors offering more competitive compensation packages. This reflects the increased demand for skilled leadership in agglomerated environments and underscores the strategic importance of human capital in achieving corporate objectives and maintaining a competitive edge.

To further examine these dynamics, the study conducts a subsample analysis focusing on selected group of states in the U.S.. The subsample analysis provides a deeper understanding of how geographic density affects corporate governance and executive compensation within these specific contexts, highlighting any regional variations in governance outcomes and compensation strategies. By comparing the results from the full sample to these state-specific findings, the research offers nuanced insights into how different business environments influence the strategic advantages of geographic clustering.

The research provides practical implications for policymakers and practitioners by highlighting the benefits of geographic clustering. The study suggests that regional development policies should consider the strategic value of fostering geographic competitive

networks to enhance economic growth and competitiveness. Firms can leverage these insights to optimize governance structures and compensation strategies, thereby strengthening their position in an increasingly interconnected market. Overall, this study offers a comprehensive analysis of the strategic implications of geographic density, challenging traditional assumptions about competitive distance and providing a nuanced understanding of the interplay between geography and corporate governance. By integrating theoretical insights with empirical evidence, the research contributes to a deeper understanding of how firms can harness location-based synergies to drive strategic success.

The remainder of this paper is structured as follows: Section 2 delves into hypothesis development, exploring the theoretical background and literature that inform our research questions. Section 3 details the methodological approach, including data sources, sample selection, and the measurement of geographic density. Section 4 presents the empirical analysis and results, examining the impact of geographic density on board characteristics and CEO compensation. Finally, Section 5 concludes with a discussion of the findings, implications for corporate governance practices, and suggestions for future research.

2. Hypotheses development

2.1 Board characteristics

Board characteristics such as independence, expertise, and diversity are integral to shaping firm strategy and governance. A substantial body of empirical research underscores how the size and independence of a board are shaped by the directors' costs of acquiring information. Studies by Boone et al. (2007), Coles et al. (2008), and Linck et al. (2008) provide significant insights into this relationship, emphasizing the financial and strategic implications of these costs. Additionally, geographic density is a critical factor in facilitating information flow and reducing its associated costs. Alam et al. (2014) reveal compelling evidence that directors who are geographically closer to their serving boards incur lower costs in the acquisition and processing of firm-specific information. This proximity enables more frequent and effective communication, allowing board members to gain timely and relevant insights crucial for making accurate strategic decisions. By reducing informational barriers, geographic density enhances board effectiveness, ensuring that directors are well-informed and better equipped to fulfill their oversight roles.

In the context of agglomeration economies, participants in the market commonly prefer to co-locate with competitors to better access industry knowledge, a theory indicated by Marshall (1920). Connections among market participants engender externalities facilitating knowledge spillovers (McCann & Folta, 2008). Knowledge transfer plays a pivotal role in reducing the costs associated with information acquisition for board directors. Effective communication

channels, particularly those involving face-to-face interactions, are instrumental in fostering an environment where knowledge flows seamlessly among stakeholders. According to Daft and Lengel (1986), both casual and formal face-to-face contacts among market participants significantly enhance the efficiency of industrial knowledge transfer. When board directors are situated in a dense competitor network, these interactions become more frequent and substantive, providing direct access to a rich pool of industry insights and developments. This geographic connection allows directors to tap into existing knowledge networks, thereby bypassing some of the more time-consuming and costly processes involved in gathering information independently. As a result, board directors can make more informed decisions swiftly, contributing to better governance and strategic oversight. This, in turn, leads to more robust governance structures and well-informed strategic directions, ultimately contributing to the firm's long-term success.

Firms situated within dense networks of competitors are likely to have access to a richer pool of readily available industry insights and knowledge. This proximity allows for more efficient information acquisition, reducing the necessity for larger boards. When directors can tap into a local network of industry knowledge, the collective need for diverse sources of information typically covered by a greater number of board members diminishes. Consequently, firms can operate effectively with smaller boards, with each member possibly leveraging

personal connections and local insights to fulfill their oversight roles. Thus, we formalize the following hypothesis:

Hypothesis 1: The geographic density of competitor networks is inversely related to board size

Being close to a network of competitors significantly enhances board directors' exposure to independent industry practices and benchmarks, cultivating a governance culture that benefits from a wider spectrum of external viewpoints, rather than being solely reliant on internal management reports. This greater exposure facilitates a governance environment where board decisions are influenced by a comprehensive array of independent insights, thereby reinforcing the board's autonomy and ability to effectively oversee management practices. Following the insights from Knyazeva et al. (2013), who suggest that a fluent supply of directors promotes board independence, we posit that geographic density substantially improves the supply of specialized talents within the industry. This increased availability of skilled professionals enlarges the pool of potential directors, enhancing the board's diversity in terms of viewpoints and expertise. Such diversity is crucial for fostering independent thought and decision-making among board members, thereby contributing significantly to overall board independence. The enhanced board independence, driven by both increased exposure to independent practices and a richer pool of specialized talents, culminates in a more robust governance structure. It equips directors more effectively for their oversight roles, ensuring

they can perform critical governance functions with a higher degree of efficacy and independence. Thus, we conjecture the following hypothesis:

Hypothesis 2: The geographic density of competitor networks positively affects board independence

The presence of numerous competing firms within a geographically confined area significantly enhances the networking potential for directors, not just among themselves, but across various professional domains. This high-density environment fosters opportunities for directors to engage with a broader array of stakeholders, including potential clients and industry experts beyond their immediate board responsibilities. The continuous interaction within such a network-rich locale encourages the development and expansion of directors' personal and professional networks, extending far beyond interactions with other directors to encompass a wide range of industry-related contacts. Therefore, we propose the following hypotheses:

Hypothesis 3a: The geographic density of competitor networks positively correlates with the enlargement of board directors' professional network size

Hypothesis 3b: The geographic density of competitor networks positively correlates with the enlargement of CEOs' professional network size

2.2 Executive educational background

A high density of competitor networks within a geographic region significantly enhances the supply of qualified potential directors, particularly those with superior educational backgrounds. This concentration of industry-specific firms cultivates a competitive environment that not only attracts top-tier talent but also incentivizes continuous professional

development. The presence of industry concentration in proximity creates a robust market for directors, where the demand for governance excellence drives the supply of individuals who have pursued advanced education and possess extensive experience in their respective fields. This dynamic facilitates the pooling of a diverse array of directors whose educational achievements and industry expertise align with the high standards required for effective corporate governance. As firms vie to bolster their boards with the best available talent, the overall quality of governance in the region is elevated. This scenario underscores the critical role that geographic clustering of competitor networks plays in enhancing the quality of board candidates, thereby strengthening corporate governance frameworks across the clustered firms. Thus, we suggest the following hypotheses:

Hypothesis 4a: The geographic density of competitor networks is positively associated with superior educational backgrounds of board members

Hypothesis 4b: The geographic density of competitor networks is positively associated with superior educational backgrounds of executive managers

2.3 Executive compensation

The concept articulated by Marshall (1920) highlights that the clustering of specialized labor is another key externality promoting agglomeration economies. Specialized labor refers to employees who develop industry-specific human capital to meet unique industry demands

(Ganesan et al., 2005), and its accumulation is greatly facilitated by the geographic density of competitor networks. The geographic concentration of industry competitors creates a dense market for employees with specialized skills, as noted by Krugman (1991). Moreover, firms within a dense network of competitors experience unique dynamics that influence CEO and board member compensation. The competitive environment necessitates the attraction and retention of top executive talent, often leading to increased compensation packages. The presence of numerous competing firms within close proximity enhances the professional network and fosters knowledge transfer, creating a dynamic labor market that demands competitive compensation to secure top-tier talent. Francis et al. (2016) suggest that firms in agglomerated environments not only benefit from a larger talent pool but also face pressure to offer higher pay to remain attractive to the best candidates. Additionally, the concentration of competitors in a specific geographic area creates a robust local labor market for directors. The availability of a qualified director pool locally enables firms to enhance their governance structures, which in turn increases the need to offer competitive compensation packages to attract and retain these high-caliber directors. Thus, we suggest the following hypotheses:

Hypothesis 5a: The geographic density of competitor networks is positively associated with higher board member compensation

Hypothesis 5b: The geographic density of competitor networks is positively associated with higher CEO compensation

In addition to the immediate impact on compensation levels, we suggest that the growth of compensation for CEOs and board members is also positively influenced by the density of competitor networks. CEOs in densely networked environments benefit from accelerated learning and enhanced professional networks. This faster learning curve and broader network enable them to make more informed decisions and drive superior firm performance, which in turn justifies higher compensation growth. Therefore, we propose:

Hypothesis 6a: The geographic density of competitor networks is positively associated with the growth of board member compensation

Hypothesis 6b: The geographic density of competitor networks is positively associated with the growth of CEO compensation

These hypotheses highlight the multifaceted impact of competitor geographic density on both the level and growth of compensation for CEOs and board members. The dynamic environment fosters rapid learning and extensive networking, leading to sustained increases in compensation as executives leverage their enhanced capabilities and connections to drive firm success.

3. Methodology

3.1 Geolocation information

The first step in our methodology involved constructing a comprehensive sample of U.S. publicly listed firms by extracting a list of domestically listed companies along with their

complete headquarters addresses from the Compustat database. The accuracy of these headquarters locations is crucial for understanding the spatial relationships between firms, as geographic density is a key variable in our analysis. To transform these addresses into precise geographic data, we utilized the Google Cloud Platform's *Geocoding API*. This service is known for its reliability and efficiency in converting human-readable addresses into geographic coordinates, specifically latitude and longitude, which are essential for calculating geographic distances between firms.

The *Geocoding API* allows us to automate the process of obtaining geographic coordinates, ensuring consistency and accuracy across a large dataset. However, some firms provide non-specific headquarters addresses that cannot be pinpointed precisely by the Geocoding API. In such cases, we used zip codes as a fallback method to approximate geographic locations. By using zip codes, we ensured that even those firms with incomplete address information were included in the analysis, albeit with slightly less precision. Overall, we successfully derived geographic coordinates for 99% of the firms in the Compustat database, with only about 2% relying on zip code-based coordinates. This high level of accuracy is pivotal for measuring the geographic density of competitor networks and supports robust analysis of spatial economic phenomena.

3.2 *TNIC* data

To accurately assess the effects of geographic density on corporate governance, we employed the Text-based Network Industry Classifications (TNIC) dataset, which provides a nuanced approach to identifying industry boundaries. Traditional industry classification systems such as SIC or NAICS have limitations that can lead to misclassification and outdated industry categorizations (Hoberg & Phillips, 2018). These systems often do not reflect the dynamic nature of businesses that frequently adapt and evolve. Furthermore, they struggle to classify firms operating across multiple industry segments since only one industry code is assigned, resulting in inaccurate representations of competitive landscapes.

The TNIC dataset addresses these shortcomings by utilizing advanced text-parsing algorithms to analyze detailed business descriptions from firms' annual 10-K filings. These filings are legally required to provide accurate and up-to-date information, making them a reliable source for understanding firms' competitive positions. The TNIC system dynamically identifies direct competitors based on the similarity of product descriptions, allowing us to map out a firm's competitive network with greater precision. Unlike static traditional classifications, TNIC generates a unique set of direct competitors for each focal firm, updating annually according to changes in products and services. This approach not only ensures an apples-to-apples comparison but also provides valuable insights into evolving industry dynamics over time. Our study period spans from 1997 to 2019, allowing us to capture changes in competitive networks and evaluate their impact on corporate governance practices accurately.

3.3 Geographic Density

To quantify the geographic density of a firm's competitor network, we calculate the geographic distance between a focal firm *i* and its direct competitor *j* at a given year *t* using the Haversine formula. This formula is widely used in geospatial analysis to determine the great-circle distance between two points on the Earth's surface based on their latitude (φ) and longitude (λ). The Haversine formula is expressed as follows:

$$a_{i,t,j} = \sin^2\left(\frac{\Delta\varphi_{i,t,j}}{2}\right) + \cos\varphi_{i,t} * \cos\varphi_{j,t} * \sin^2\left(\frac{\Delta\lambda_{i,t,j}}{2}\right)$$

$$c_{i,t,j} = 2 * \operatorname{atan2}\left(\sqrt{a_{i,t,j}}, \sqrt{1 - a_{i,t,j}}\right)$$

$$distance_{i,t,j} = R * c_{i,t,j} \quad (1)$$

where φ is latitude, λ is longitude, and R is earth's mean radius. This method provides the shortest path over the earth's surface between two firms, offering a precise measure of spatial proximity. The calculation of geographic distances is foundational to assessing how firms' locations impact their strategic interactions and governance practices.

However, geographic distance alone does not fully capture the complexities of competitive networks. To address this, we introduce the concept of weighted strength, a metric that incorporates both the number of competitors and the strength of connections within the network. The weighted strength of a firm's competitor network is calculated as:

$$weighted\_strength_{i,t} = \sum_{j \in s}^{j} \frac{1}{distance_{i,j,t}} \quad (2)$$

This measure reflects the geographic density of a firm's competitive network at year t, highlighting the concentration and closeness of competitors. Unlike traditional measures that focus solely on geographic distance, weighted strength offers a more comprehensive view of geographic density by considering the intensity of interactions between a firm and its competitors. This approach is crucial for understanding how geographic density influences board characteristics and CEO compensation, as it captures the effects of proximity on information flow, strategic interactions, and governance decisions.

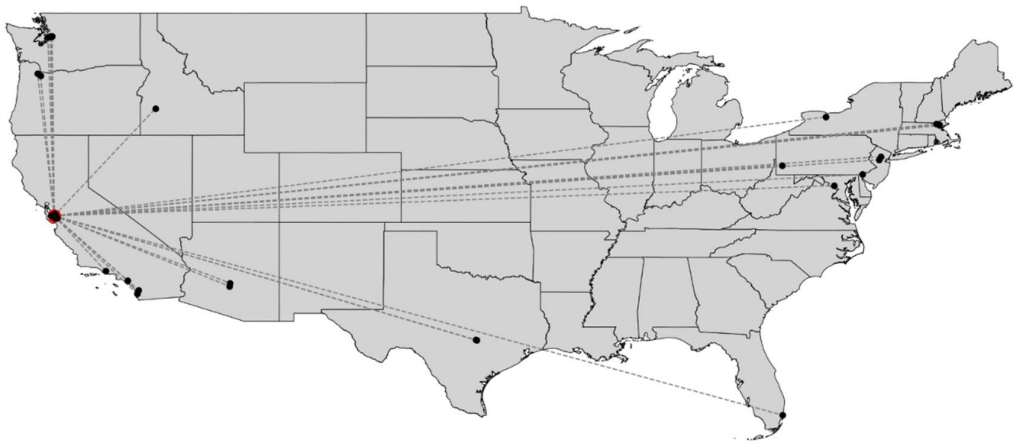

Fig 1. Geographic Competitor Network of Nvidia in 2019

Fig 1 shows one example, Nvidia's competitor network, across the United States in 2019. Each point represents a competitor identified by the Text-based Network Industry Classifications (TNIC), with the size of the points indicating the presence of competitors. The lines illustrate the geographic distance between Nvidia and its competitors, highlighting the

spatial connections that define Nvidia's competitive landscape. This visualization emphasizes the strategic role of geographic proximity in shaping Nvidia's interactions within its market.

3.4 Board and CEO characteristics

To examine the relationship between geographic density and corporate governance, we collected data on firm, board, and director characteristics, including CEO data, from BoardEX. This dataset is known for its extensive coverage of corporate governance information, making it an ideal source for analyzing the effects of geographic density on board dynamics. We obtained corporate proxy statements and Board Analyst reports to gather detailed information on board structure, including board size, composition, and compensation, as well as individual director attributes such as age, tenure, professional qualifications, and professional network size.

BoardEX data provides insights into the educational and professional backgrounds of board members, allowing us to assess the diversity and expertise present in boardrooms. The professional network size of directors is particularly relevant in the context of geographic density, as it reflects their ability to access and utilize external information and resources. Additionally, we collected information on CEO compensation, age, tenure, network size, and whether the CEO serves as the board chair. These variables enable us to explore how geographic density affects not only board composition but also the strategic roles and incentives of top executives. By analyzing these characteristics, we aim to understand how proximity to

competitors influences governance structures and decision-making processes, ultimately impacting firm performance and strategic outcomes.

3.5 Baseline control variables

We include standard controls employed in the corporate finance literature to explain firm performance. Firm size, leverage, cash holding, and the natural log of the firm's age are included in all specifications. Moreover, the economic conditions of firms may also influence firm performance, and thus we control state-level GDP per capita to account for the impact of local economies. The inherent attributes of different industries also play an important role. For instance, the high-tech industry is more likely to have better outcomes in market valuation. Industry fixed effects are still necessary to capture invariant and unobservable industry characteristics. Although traditional methods, like *SIC* and Fama-French industry classification, do not provide accurate identifications for direct competitors as the *TNIC* designation, they are still a viable solution to capture time-invariant and unobservable industry characteristics. Thus, industry fixed effects grouped by Fama-French 48 industries and year fixed effects are also included for all specifications to account for unobservable characteristics.

3.6 Fixed effects model

The empirical strategy employs a fixed-effects regression model to control for unobserved heterogeneity and isolate the effects of geographic density on the variables of interest. The fixed-effects model accounts for industry- and year-specific characteristics that may influence

board and CEO dynamics, thereby providing a robust estimation framework for assessing the impact of geographic density. The regression model is specified as follows:

$$Y_{i,t+1} = \beta\ density_{i,t} + \gamma Z_{i,t} + industry_k + year_t + \varepsilon_{i,t} \qquad (3)$$

where $Y_{i,t+1}$ represents the dependent variable of interest (e.g., board size, CEO compensation), $density_{i,t}$ is the measure of geographic density, $Z_{i,t}$ is a vector of control variables, $industry_k$ is a industry fixed effect, $year_t$ is a time fixed effect, and $\varepsilon_{i,t}$ is the error term. This approach allows for a detailed examination of how geographic density affects corporate governance while controlling for firm-specific and time-varying factors.

This methodological approach enables us to dissect the influence of geographic density on corporate governance, accounting for potential confounding factors and providing insights into how spatial proximity shapes strategic interactions and decision-making within firms. Through this rigorous empirical framework, we aim to contribute to a deeper understanding of the complex interplay between geographic density and governance outcomes in the corporate landscape.

4. Result

4.1 Descriptive statistics

Descriptive statistics for the variables utilized in this study are presented in Table 1. The data focuses on board characteristics, CEO attributes, and firm-level controls. The sample comprises a comprehensive dataset with varying observations for each variable, reflecting the extensive scope of our study. To mitigate the impact of outliers, all continuous variables are winsorized at 0.5% on both ends. The sample includes 8,921 unique firms and 65,390 firm-year observations, spanning from 1997 to 2019. This extensive dataset offers insights into how geographic density and other factors affect corporate governance structures and outcomes across a broad cross-section of the U.S. market.

The variable weighted_strength, which measures geographic density, has a mean of 1.505 and a standard deviation of 3.540, with values ranging from a minimum of close to zere to a maximum of 42.97. The median value is 0.239. This distribution indicates that while the majority of firms have relatively moderate geographic density, there is a significant spread in the data, with some firms exhibiting very high geographic density. The range of values suggests considerable variation in the degree of network connectivity among firms in the sample.

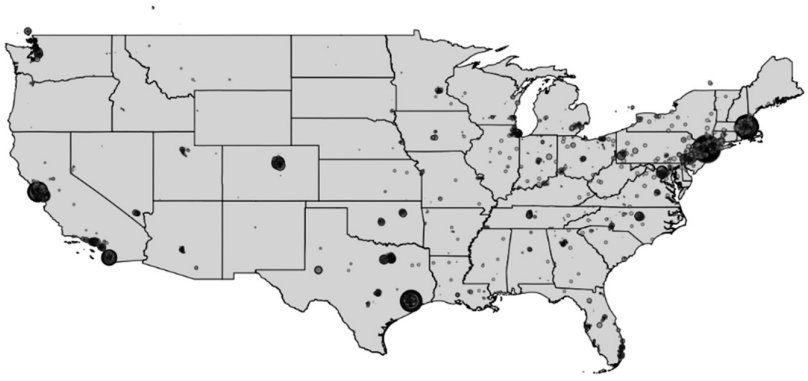

Fig 2. Geographic Density of Firm Networks in the U.S. (2019)

Fig 2 is a plot of firm-level geographic density across the United States for the year 2019. This map illustrates the distribution and concentration of firms by overlaying black circles on a map of the U.S., with each circle representing a specific location's geographic density. The size of each circle is indicative of the weighted strength of geographic density, meaning that larger circles denote areas with a higher density of competitor networks. This suggests that these locations have more firms and stronger connections, reflecting the intensity of competitive interactions within those regions.Key regions of high density are visible in areas such as the Northeast, including major cities like New York City, Boston, and Philadelphia; the Midwest around Chicago; the South with hubs in Houston, Dallas, and Atlanta; and the West Coast, particularly in Los Angeles, San Francisco, and Seattle. These areas are known economic centers, demonstrating substantial business activity and the presence of dense competitor networks. The visualization thus captures not only the geographic density of firms but also the intensity of interactions that occur within these networks. Larger circles on the map indicate areas where firms experience increased information flow and strategic interactions, factors that

are crucial for influencing corporate governance, board characteristics, and executive compensation.

The natural log of the number of board members (board_size) has a mean of 2.183 and a standard deviation of 0.329, with a median of 2.197. Exponentiating these values reveals that the average number of board members is approximately 8.85, and the median is about 9.00. This indicates that most firms have between 8 to 9 board members. The variable ceo_chair indicates that approximately 47.7% of firms have a CEO who also serves as the board chair, suggesting a notable incidence of dual roles over the sample period. Board compensation, measured as Compen_board, averages 7.323 with a substantial standard deviation of 1.660, reflecting considerable variability in compensation levels. Similarly, Pay_board shows an average of 8.950 and a standard deviation of 2.110, pointing to even greater dispersion in board pay, with a median of 9.433. CEO compensation, as indicated by Compen_CEO, averages 6.970 with a standard deviation of 1.121, while Pay_CEO reveals a higher mean of 8.982 and a standard deviation of 1.366, highlighting significant variation in CEO pay packages. Educational qualifications of board members and CEOs also exhibit diversity: 30.5% of board members hold an MBA, and 7.28% have a PhD, whereas 39.1% of CEOs possess an MBA and 7.09% hold a PhD. Finally, the board_networksize and ceo_networksize variables, with means of 1,561 and 1,299 respectively, underscore extensive professional network connections, indicating substantial variation in network size.

Additional control variables such as ROA_lag, leverage_lag, cashholding_lag, ln_mc_lag, and ln_firm_age offer insights into firm performance, financial structure, and maturity. For instance, ROA_lag has a mean of -0.0428, indicating varied profitability across firms, while leverage_lag averages at 0.231, showing the typical capital structure balance of the sample firms. ln_firm_age with a mean of 2.837 suggests that the sample predominantly includes firms with considerable operational history.

[Insert Table 1 about here]

4.2 Geographic density and Board Size, Independency

As hypothesized, we propose that geographic density is inversely related to board size. This variable *Board_size* represents the natural logarithm of the number of board members for a focal firm *i* at year *t+1*.

[Insert Table 2 about here]

Table 2 presents the regression results examining the influence of geographic density on board size. The coefficient on *weighted_strength* is -0.00345, significant at the 1% level with a t-statistic of -9.688, indicating a strong inverse relationship between geographic density and board size. This means that as the density of a firm's competitor network increases, the number of board members decreases, with an approximate reduction of 0.345% for each one-unit increase in geographic density. This finding aligns with a robust body of empirical research, such as Boone et al. (2007), Coles et al. (2008), and Linck et al. (2008), which highlights the

impact of directors' information acquisition costs on board size. The negative association suggests that firms positioned within denser networks—where information flows more freely and at lower costs—tend to have smaller boards. Existing studies, such as those by Alam et al. (2014), emphasize the benefits of geographic proximity between directors and their serving boards in lowering the costs of acquiring and processing firm-specific information, thereby enhancing board effectiveness. Our findings extend this understanding by suggesting that connections among competitors also contribute to reduced information acquisition costs. Such industry-level geographic density facilitates access to a broader pool of industry knowledge and insights, which in turn diminishes the necessity for larger boards. Frequent and substantive interactions within these networks allow firms to efficiently harness and utilize critical market intelligence. This dynamic supports more streamlined decision-making and governance structures, corroborating our hypothesis that the geographic density is inversely related to board size.

Other controls in the model include firm size, leverag, profitability, cash holdings, and firm age. Each of these factors also shows significant associations with board size. Notably, larger and older firms have larger boards, while more profitable and more liquid firms tend to have smaller boards. These results align with typical expectations about firm characteristics and governance structures.

[Insert Table 3 about here]

In addition to its impact on board size, geographic density also bolsters board independence by facilitating access to a broad array of external insights, thus supporting more independent governance practices. Table 3 displays the regression results examining the effect of geographic density on board independence. The coefficient on *weighted_strength* is -0.00365, significant at the 5% level (t-statistic = -2.268), indicating that firms within denser networks—where directors gain increased exposure to independent industry practices and benchmarks—are less likely to combine the roles of CEO and board chair. This negative correlation emphasizes how denser competitor networks promote governance independence by creating an environment where the reliance on a diverse range of external viewpoints and industry knowledge minimizes the need for centralized control. This result corroborates our hypothesis that the geographic density of competitor networks positively influences board independence, leading to a governance framework where directors are more capable of challenging management and integrating diverse perspectives into board deliberations.

Table 4 presents the regression results examining the effect of geographic density on the professional networks of board directors and CEOs. The coefficient on weighted_strength is 18.80 for board directors and 23.84 for CEOs, both statistically significant at the 1% level (t-statistics = 14.79 and 12.18, respectively). These results indicate that firms operating within denser networks experience a substantial expansion in the professional networks of both board directors and CEOs.

[Insert Table 4 about here]

This positive association highlights how geographic density enables both directors and CEOs to engage with a diverse range of stakeholders, including potential clients and industry experts. In such environments, frequent and substantive interactions are facilitated, leading to the enrichment of personal and professional connections for key corporate figures. The geographic density of competitor networks thus positively correlates with the enlargement of professional networks, allowing board members and CEOs to leverage extensive industry contacts that enhance governance roles and strategic insights.

Moreover, this finding aligns with the broader implications of dense networks fostering enhanced networking potential for both directors and CEOs. The expanded networks support improved strategic decision-making and governance capabilities, which are critical for firms navigating complex and competitive market landscapes. By tapping into these robust networks, firms can benefit from the collective expertise and insights of their leadership, driving innovation and maintaining a competitive edge in their respective industries.

4.3 Geographic density and educational backgroud

The regression results in Table 5 for board members, specifically examining the proportion of MBA and PhD degrees, show that geographic density positively correlates with higher educational achievements. The coefficient for board members holding MBAs (Column 1) is 0.00074 (t = 3.296), while for those holding PhDs (Column 2), it is significantly higher at

0.00167 (t = 12.22). These findings support the hypothesis that denser competitor networks enhance the educational caliber of board members. The geographical clustering of firms leads to a concentrated pool of specialized talents, facilitating access to highly educated directors who bring substantial expertise to their roles.

[Insert Table 5 about here]

In addition, the results from Columns 3 (MBA) and 4 (PhD) indicate a positive impact of geographic density on educational attainment of CEO. The coefficient in Column 4 for CEOs with PhDs is 0.00249 (t = 7.078), affirming that denser networks are associated with a higher likelihood of CEOs attaining higher academic qualifications. Although the coefficient for MBAs in Column 3 is lower at 0.00108 (t = 1.724), it still suggests a trend toward advanced business degrees among CEOs in densely networked environments.

These results supports Marshall's (1920) theory on the clustering of specialized labor and Krugman's (1991) insights into the dense markets for employees with specialized skills, highlighting how the presence of a high-density competitor network critically shapes the educational backgrounds of board members and CEOs. This network not only enhances the supply of qualified potential directors and executives but also fosters a competitive environment that promotes continuous professional development. The proximity effect within these dense networks creates a robust market for top-tier talent, where the demand for governance excellence and sophisticated management drives the supply of individuals with advanced

education and extensive experience. Consequently, this dynamic significantly enhances corporate governance by pooling a diverse array of directors and executives whose educational achievements and industry expertise meet the high standards required for effective governance, thereby elevating the overall quality of leadership and governance in clustered industry environments.

4.4 Geographic density and Compensation

Table 6 provides a comprehensive examination of the effects of geographic density on both board and CEO compensation, reflecting how agglomerated environments influence overall compensation structures. For Column (1) and (2), we examine the effects of geographic density on board compensation, where both board compensation and pay are measured in natural log values. The regression results reveal that geographic density positively correlates with board compensation. In Column (1), the coefficient for geographic density is 0.0299 (t = 2.655), indicating a significant effect at the 1% level. This suggests that an unit increase in geographic density correlates with a 2.99% increase in total board compensation, highlighting how firms in densely networked environments offer higher compensation packages to attract and retain top talent capable of navigating competitive pressures. Column (2), which examines individual board member pay, also shows a positive association with geographic density, having a coefficient of 0.0244 (t = 1.821). Although this result is not significant at the 1% level, it remains significant at the 10% level, indicating a 2.44% increase per unit increase in geographic density.

Following our analysis of board compensation, where geographic density positively correlates with higher board compensations, we turn our attention to CEO compensation. The results suggest that just as firms offer competitive packages to secure top board talent, similar dynamics are at play in the CEO market. For CEO compensation, the regression results reveal that geographic density positively correlates with CEO compensation. In Column (3), the coefficient for geographic density is 0.0148 (t = 2.786), indicating a significant effect at the 1% level. This suggests that a unit increase in geographic density correlates with a 1.48% increase in total CEO compensation, highlighting how firms in densely networked environments provide enhanced compensation packages to attract and retain top executive talent capable of navigating competitive pressures. Column (4), which examines individual CEO pay, also shows a positive association with geographic density, having a coefficient of 0. 0133 (t = 3.043), indicating a 1.33% increase in individual CEO pay per unit increase in geographic density.

In summary, these results support both of our Hypotheses 6a&b. It demonstrates that firms in densely networked environments provide enhanced compensation opportunities for both board members and CEOs to attract and retain top talent.

However, results regarding the annual growth of CEO compensation and pay, detailed in Appendix A.2, show significance levels exceeding 10% and do not support our hypothesis about positive growth being associated with a dense competitor network. This suggests that while a dense competitor network may enhance the level of CEO compensation, it may not

directly impact the growth rate. One possible reason for this could be that firms in such environments may already offer competitive compensation packages, leading to less variation in growth rates, as the primary focus shifts to maintaining high compensation levels rather than driving substantial increases.

4.5 Geographic density in selected states

In this section, we narrow our analysis to a selected group of states—California, New York, and Texas—which are characterized by a high concentration of high-tech firms and serve as major hubs for business innovation and technological advancement in the United States. These states not only house a significant portion of the nation's firms but also exhibit strong geographic density due to their competitive and collaborative business environments. To illustrate the significance of these states within our full sample, Figure 3 presents a pie chart highlighting the major proportion of firms incorporated in California, New York, and Texas. This visual representation underscores the dominance of these states in the overall corporate landscape. By focusing on these high-tech states, we aim to explore how geographic density in such concentrated environments influences board and CEO characteristics, shedding light on the unique dynamics at play in these pivotal markets.

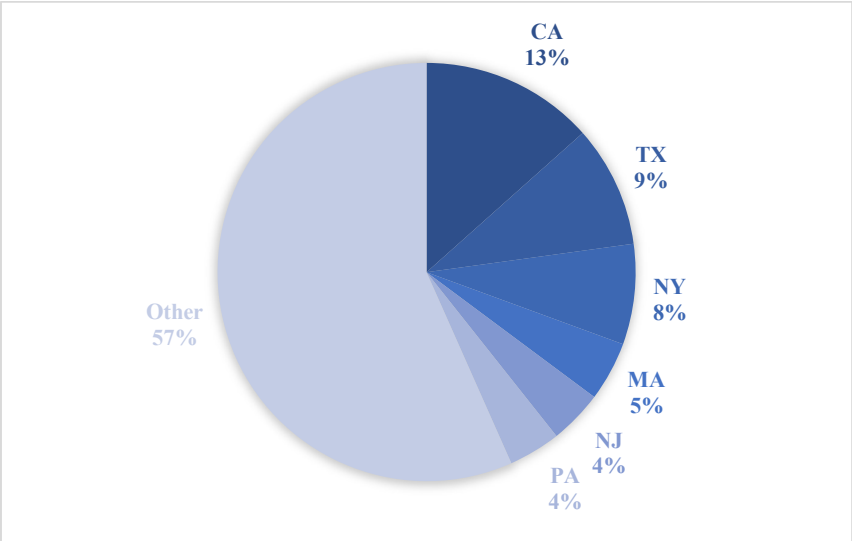

Fig 3 Represents the average percentage of firms incorporated in the United States, broken down by state, for the years 1997 through 2019

For the subsample analysis, we specifically selected firms incorporated within the states of California, New York, and Texas. In order to maintain consistency in our evaluation of geographic density, we imposed a restriction that both the focal firm and its identified competitors must be located within the same state. This approach ensures that the competitive dynamics and network interactions are analyzed within geographically consistent environments. Additionally, we conducted a robustness check by testing a subsample without restrictions on competitors' locations, and the results remained largely consistent with our primary findings. The imposition of these geographic restrictions resulted in a reduction of the subsample size from over 65,000 to approximately 20,000 firm-year observations. Despite this reduction, the subsample size remains sufficiently large to conduct robust statistical analyses, ensuring that our findings are both reliable and representative of the high-tech environments in these key states.

Table 7 displays the regression results for the subsample. Column (1) emphasizes the role of geographic density in shaping board size. The coefficient on weighted_strength is -0.00422, which is statistically significant at the 1% level (t-statistic = -9.330). This suggests that a unit increase in geographic density correlates with a 0.422% decrease in the size of serving board directors. This negative relationship indicates that firms operating in environments characterized by dense networks tend to have smaller boards. Compared to the results from Table 2 of the entire US sample, the effect of geographic density on board size is more pronounced in the subsample of high-tech states. This heightened effect can be attributed to several factors. First, these states serve as major hubs for technological innovation and business activity, leading to highly competitive and dynamic business environments. The intense competition in these regions necessitates quicker decision-making and more agile governance structures, which smaller boards can facilitate. Additionally, the presence of a dense network of high-tech firms creates a rich ecosystem of information exchange, allowing companies to capitalize on shared industry insights and knowledge. Still, these findings corroborate prior studies that emphasize the efficiency gains from improved information flows in network-dense environments, highlighting how firms can optimize board structures in regions marked by technological innovation and industry concentration.

Compared to the full sample, where negative effects of of geographic density on CEO-Chair duality are statistically significant, firms in the selected high-tech states do not appear

less likely to combine the CEO and chair roles. Column (2) in Table 7 presents the regression results for the subsample. The coefficient on weighted_strength is -0.000527, which is not statistically significant (t-statistic = -0.268). Although this result suggests that geographic density does not significantly impact the likelihood of a CEO also holding the chair position in this subsample, it still reveals a negative trend with lower value. This tendency can be attributed to the unique characteristics of states, which are recognized for their innovation-driven economies and dynamic business environments. While the subsample results do not show a significant impact of geographic density on CEO-Chair duality, they highlight a strategic preference for firms in high-tech states to separate these roles.

Columns (3) to (6) in Table 7 present the regression results for the subsample, specifically examining the relationship between geographic density and the educational backgrounds of board members and CEOs. The analysis reveals that geographic density positively correlates with higher educational achievements among both directors and CEOs, consistent with our hypotheses on the influence of densely networked environments on talent selection. Column (3) and (4) focus on board members, where the coefficients indicate a notable relationship between geographic density and educational attainment. The coefficient for board members holding MBAs is 0.000934 (t = 3.412), while for those holding PhDs, it is 0.002685 (t = 4.598). Column (5) and (6) shift the focus to CEOs, revealing a similar trend. The regression results show that geographic density positively correlates with CEOs' educational backgrounds, with the

coefficient for MBAs being 0.00257 (t = 3.386) and for PhDs being 0.00269 (t = 4.348). These results suggest that firms located in selected states with higher geographic density tend to have excutives with more advanced educational qualifications.

When comparing these findings to the full sample, where the coefficients for board members holding MBAs and PhDs were 0.00074 (t = 3.296) and 0.00167 (t = 12.22) respectively, it becomes evident that the selected states exhibit a stronger correlation between geographic density and educational background. Similarly, for CEOs, the full sample showed coefficients of 0.00108 (t = 1.724) for MBAs and 0.00249 (t = 7.078) for PhDs, indicating that the selected states present more pronounced effects.

The pronounced effects of geographic density on educational backgrounds in the selected states can be attributed to several critical factors. First, the high concentration of technology-driven industries in these regions inherently demands specialized skills and advanced education, creating a competitive environment where geographic density amplifies the educational achievements of corporate leaders. Firms in these states are more likely to seek out highly qualified individuals capable of navigating the complex and rapidly evolving landscape of technology, resulting in a stronger correlation between geographic density and educational attainment. Additionally, the robust economies and innovation hubs characteristic of these states naturally attract individuals with higher average educational qualifications. The presence of prestigious universities, research institutions, and tech clusters fosters an environment that

draws educated professionals to opportunities in these areas, leading to an already elevated baseline level of education. This existing high standard allows geographic density to further accentuate the importance of advanced degrees and specialized skills among corporate leaders. Moreover, the competitive nature of these states means that firms prioritize the recruitment of executives and board members whose educational qualifications align with their strategic goals. This strategic focus on quality over quantity results in a more pronounced effect of geographic density, as firms leverage dense networks to identify and recruit top-tier talent that meets the high standards required for effective governance and leadership. Therefore, while the effects of geographic density on educational backgrounds are more pronounced in the selected states, it is evident that geographic density continues to play a crucial role in shaping the educational caliber of key corporate figures across various environments. The preference for quality in educational qualifications allows firms to leverage high-impact connections and specialized expertise, effectively navigating competitive pressures and enhancing governance practices.

Column (7) and (8) present the regression results for the subsample analysis, focusing on the network size of board directors and CEOs in selected states. The coefficient for board_networksize is 7.260 (t-statistic = 4.850), while for ceo_networksize, it is 12.03 (t-statistic = 5.360). These findings suggest that geographic density exerts a positive influence on the expansion of professional networks for both board directors and CEOs. However, the effects

observed in the subsample are less pronounced than those in the full sample, where the coefficients are 18.80 for board directors and 23.84 (Table 4) for CEOs, respectively.

The diminished effect observed in the selected states can be attributed to two main factors. First, CEOs and directors in California, New York, and Texas may already possess a higher average network size due to the inherent advantages of being located in regions with high firm density and intense business activity. The baseline network size is substantial in these hubs, meaning the incremental impact of geographic density on further expanding these networks might be less pronounced.

Second, the nature of the competitive landscape in these selected states requires a more strategic and focused networking approach. In such dynamic environments, the emphasis might shift from broad network expansion to the cultivation of high-impact, strategic connections. Directors and CEOs may prioritize forming alliances with key stakeholders, such as potential clients and industry experts, who can provide significant strategic value and competitive advantages. This focus on quality over quantity suggests that while the quantitative growth in network size may appear subdued, the qualitative aspects of these connections are of paramount importance.

Despite the reduced quantitative effect, geographic density still plays a crucial role in enhancing the professional networks of key corporate figures in the selected states. The dynamics within these hubs emphasize the need for strategic networking, where firms can

leverage pivotal connections to navigate competitive pressures effectively and enhance governance practices. This underscores the notion that while the broad expansion of networks might be less visible, the qualitative value derived from these high-impact connections remains instrumental in driving strategic decision-making and governance in densely networked environments.

Column (9) to (12) in Table 7 provide a comprehensive examination of the effects of geographic density on both board and CEO compensation within the selected states, reflecting how agglomerated environments influence overall compensation structures. The regression results reveal that geographic density positively correlates with board compensation. In Column (9), the coefficient for geographic density is 0.0351 (t = 2.701), indicating a significant effect at the 1% level. This suggests that a unit increase in geographic density correlates with a 3.51% increase in total board compensation. Column (10), which examines individual board member pay, also shows a positive association with geographic density, with a coefficient of 0.0295 (t = 1.98). This result is significant at the 5% level, indicating a 2.95% increase per unit increase in geographic density. These results emphasizes how firms in densely networked environments within these states offer higher compensation packages to attract and retain top talent capable of navigating competitive pressures.

In addiction, the results suggest that just as firms offer competitive packages to secure top board talent, similar dynamics are at play in the CEO market. For CEO compensation, the

regression results reveal that geographic density positively correlates with CEO compensation. In Column (11), the coefficient for geographic density is 0.0348 (t = 2.696), indicating a significant effect at the 1% level. This suggests that a unit increase in geographic density correlates with a 3.48% increase in total CEO compensation. Column (4), which examines CEO pay, also shows a positive association with geographic density, having a coefficient of 0.0291 (t = 3.023), indicating a 2.91% increase in CEO pay per unit increase in geographic density.

In comparing these findings to the results from the full sample, we observe that the effects of geographic density on compensation for both board and CEO are more pronounced in the selected states. The reasons for these more pronounced effects in the selected states could be attributed to two main factors. First, the selected states serve as major hubs for technological innovation and business activity, which increases competition for top talent. This competitive environment necessitates offering more attractive compensation packages to attract and retain skilled board directors and CEOs. Second, the concentration of firms in these states creates a rich ecosystem for networking, allowing firms to leverage connections more effectively to gain strategic advantages. As a result, the premium placed on compensating board members and CEOs reflects the strategic importance of human capital in driving firm performance and innovation in these regions.

In conclusion, the subsample analysis reaffirms our hypotheses that geographic density positively influences compensation structures for both board directors and CEOs. The results

demonstrate that firms within densely networked environments in the selected states are particularly likely to offer enhanced compensation to attract and retain top talent, aligning with prior research on the strategic importance of human capital in competitive, innovation-driven markets.

5. Conclusion

Our study demonstrates that firms situated within dense competitive networks benefit from smaller and more independent boards, enriched by executives with diverse educational backgrounds and extensive professional networks. These findings underscore the importance of geographic density in enhancing board effectiveness, strategic decision-making, and overall governance quality. Furthermore, the study reveals that geographic density is positively associated with higher CEO compensation. Firms in densely clustered environments are compelled to offer competitive compensation packages to attract and retain top executive talent, reflecting the increased demand for skilled leadership in agglomerated settings. This finding emphasizes the strategic importance of human capital in maintaining a competitive edge and achieving corporate objectives.

By conducting a subsample analysis focused on a selected group of states, our research provides nuanced insights into how geographic density impacts corporate governance and compensation within these high-density, innovation-driven environments. This analysis confirms that while the overall trends hold true, regional variations exist, offering a more detailed understanding of how geographic density influences governance structures across different contexts.

The implications for corporate governance are profound, suggesting that firms should consider geographic density as a strategic asset that can be leveraged to optimize governance

structures and compensation strategies. By understanding the impact of competitive clustering, firms can design more efficient board compositions and attract high-caliber executives who are capable of navigating complex market dynamics. Additionally, recognizing the pressures of geographic density on executive compensation can help firms strategically position themselves to retain essential leadership and sustain competitive advantages.

For policymakers, these findings advocate for the strategic development of regional clusters that foster competitive networks, thereby driving economic growth and innovation. By supporting geographic clustering, policymakers can create environments that encourage the exchange of ideas, skills, and resources, ultimately leading to more robust corporate governance practices and enhanced firm performance.

Future research should continue to explore the nuances of geographic density and its implications for corporate governance across different industries and geographic contexts. While this study focuses on U.S. firms, examining similar dynamics in international settings could provide valuable insights into the global applicability of these findings. Additionally, future studies might investigate the long-term effects of geographic density on firm sustainability, further elucidating the strategic advantages of competitive networks. Examining the role of geographic density in shaping other aspects of executive compensation structures, such as performance-based incentives, could also offer deeper insights into how firms align leadership strategies with market conditions.

References

Abdoh, H. (2021). Firm-Specific Industries, Volatility, and Return: A Text-Based Network Industrial Classification Approach. *Journal of Portfolio Management, 47*(8), 184-196. doi:10.3905/jpm.2021.1.253

Ben Letaifa, S., Rabeau, Y. (2013). Too close to collaborate? How geographic proximity could impede entrepreneurship and innovation. *Journal of Business Research, 66*(10), 2071-2078. doi:10.1016/j.jbusres.2013.02.033

Chauvin, J. (2019). When Distance Shrinks: The Effects of Competitor Proximity on Firm Survival. *Manuscript under review at Management Science*.

Chen, M.-J. (1996). Competitor Analysis and Interfirm Rivalry: Toward a Theoretical Integration. *The Academy of Management Review, 21*(1), 100-134. doi:10.2307/258631

Combes, P.-P., Duranton, G., Gobillon, L., Puga, D., Roux, S. (2012). The Productivity Advantages of Large Cities: Distinguishing Agglomeration From Firm Selection. *Econometrica, 80*(6), 2543-2594. doi:https://doi.org/10.3982/ECTA8442

Combes, P.-P., Gobillon, L. (2015). The Empirics of Agglomeration Economies. *Handbook of Regional & Urban Economics, 5*, 247-348. doi:10.1016/B978-0-444-59517-1.00005-2

Ganesan, S., Malter, A.J., Rindfleisch, A. (2005). Does Distance Still Matter? Geographic Proximity and New Product Development. *Journal of Marketing, 69*(4), 44-60. doi:10.1509/jmkg.2005.69.4.44

Giroud, X., Mueller, H.M. (2011). Corporate Governance, Product Market Competition, and Equity Prices. *The Journal of Finance, 66*(2), 563-600. doi:https://doi.org/10.1111/j.1540-6261.2010.01642.x

Hautala, J. (2011). Cognitive proximity in international research groups. *Journal of Knowledge Management, 15*(4), 601-624. doi:10.1108/13673271111151983

Hoberg, G., Phillips, G. (2010). Product market synergies and competition in mergers and acquisitions: A text-based analysis. *Journal of Political Economy, 23*(10), 3773-3811.

Hoberg, G., Phillips, G. (2016). Text-based network industries and endogenous product differentiation. *Journal of Political Economy, 124*(5), 1423-1465.

Hoberg, G., Phillips, G. (2018). Text-based industry momentum. *Journal of Financial Quantitative Analysis, 53*(6), 2355-2388.

Huber, F. (2012). Do clusters really matter for innovation practices in information technology?: Questioning the significance of technological knowledge spillovers. *Journal of Economic Geography, 12*(1), 107-126. doi:10.1093/jeg/lbq058

Krugman, P.R., 1991. Geography and trade. Leuven University Press, Leuven, Belgium.

Marshall, A., 1920. Principles of Economics. London: MacMillan.

Martin, P., Mayer, T., Mayneris, F. (2011). Spatial concentration and plant-level productivity in France. *Journal of Urban Economics, 69*(2), 182-195. doi:10.1016/j.jue.2010.09.002

McCann, B.T., Folta, T.B. (2008). Location Matters: Where We Have Been and Where We Might Go in Agglomeration Research. *Journal of Management, 34*(3), 532-565. doi:10.1177/0149206308316057

Sorenson, O., Audia, P.G. (2000). The social structure of entrepreneurial activity: Geographic concentration of footwear production in the United States, 1940–1989. *American Journal of Sociology, 106*(2), 424-462.

Vogel, J. (2008). Spatial Competition with Heterogeneous Firms. *The Journal of Political Economy, 116*(3), 423-466. doi:10.1086/589891

Francis, B., Hasan, I., John, K., & Waisman, M. (2016). Urban agglomeration and CEO compensation. *Journal of Financial Economics, 121*(2), 308-328.

Table 1 - Summary statistics

This table presents summary statistics including the number of observations (N), mean, standard deviation (sd), and percentiles (p1, p50, p99) for various measures related to geographic density, board composition, CEO characteristics, network size, compensation, and firm performance metrics. The dataset primarily consists of publicly traded domestic firms in the US market during the sample period from 1997 to 2019. Detailed definitions and constructions of each variable can be found in Appendix Table A1.

VARIABLES	N	mean	sd	p1	p50	p99
Proximity measure						
weighted_stregth	68,362	1.505	3.540	6.38e-05	42.97	0.000421
board_size	68,362	2.183	0.329	0	3.638	1.386
ceo_chair	15,726	0.477	0.499	0	1	0
board_MBA	68,362	0.305	0.194	0	1	0
board_PhD	68,362	0.0728	0.114	0	1	0
ceo_MBA	68,362	0.391	0.488	0	1	0
ceo_PhD	68,362	0.0709	0.257	0	1	0
board_networksize	68,362	1,561	1,069	1	19,129	77.25
ceo_networksize	68,362	1,299	1,523	1	20,159	17
Compen_board	2,099	7.323	1.660	0	11.01	0
Pay_board	2,099	8.950	2.110	0	13.10	0
Compen_CEO	8,897	6.970	1.121	0	10.68	0
Pay_CEO	8,897	8.982	1.366	0	15.72	5.620
ROA_lag	67,953	-0.0428	0.293	-3.075	0.588	-1.333
leverage_lag	67,820	0.231	0.245	0	1.984	0
cashholding_lag	68,105	0.192	0.231	0	0.945	0.000436
ln_mc_lag	65,744	6.412	2.015	0	13.67	2.119
ln_firm_age	68,362	2.837	0.763	0	4.304	1.099

Table 2 - Multivariate regression for geographic density and board size

This table presents the results of multivariate regressions examining the relationship between geographic density and board size. Geographic density, captured by the variable "weighted_strength," is defined as the weighted sum of the reciprocals of geographic distances between a focal firm and its competitors, identified by TNIC designations. Board size is measured as the natural logarithm of the number of board members. The regression model employs robust standard errors and includes fixed effects for industry and year to ensure the reliability and contextual accuracy of the estimates. Significance levels are denoted by asterisks, where *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Further details on the construction of variables are provided in Appendix Table A1.

VARIABLES	Board_size (1)
weighted_strength	-0.00345***
	(-9.688)
ln_mc_lag	0.0716***
	(120.2)
leverage_lag	0.0672***
	(12.01)
ROA_lag	-0.102***
	(-18.82)
cashholding_lag	-0.108***
	(-17.66)
ln_firm_age	0.0461***
	(27.84)
Constant	1.616***
	(277.3)
Observations	65,390
R-squared	0.356
Industry FE	√
Year FE	√
Robust SE	√

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3 - Multivariate Regression for Geographic Density and CEO-Chair Dual Role

This table presents the results of multivariate regressions exploring the relationship between geographic density and the probability of a CEO also serving as the chairman of the board. Geographic density, captured by the variable "weighted_strength," is defined as the weighted sum of the reciprocals of geographic distances between a focal firm and its competitors, identified by TNIC designations. The dependent variable, "ceo_chair," is an indicator variable (0 or 1) that denotes whether the CEO also holds the chairman position within the firm. The regression model utilizes robust standard errors and incorporates fixed effects for industry and year to ensure the estimates' reliability and relevance in varying contexts. Significance levels are denoted by asterisks, where *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Comprehensive details on the construction of these variables and additional methodological specifics are provided in Appendix Table A1.

VARIABLES	Ceo_chair (1)
weighted_strength	-0.00365**
	(-2.268)
ln_mc_lag	0.0292***
	(11.26)
leverage_lag	-0.0381
	(-1.616)
ROA_lag	-0.0190
	(-0.836)
cashholding_lag	-0.132***
	(-4.485)
ln_firm_age	0.0691***
	(8.940)
Constant	0.103***
	(3.890)
Observations	11,704
R-squared	0.080
Industry FE	√
Year FE	√
Robust SE	√

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 - Multivariate Regression Analysis on Network Size of Board and CEO

This table presents the results of multivariate regressions examining the impact of geographic density on the network sizes of the board and CEO. Geographic density is defined as the weighted sum of the reciprocals of geographic distances between a focal firm and its competitors, identified by TNIC designations. The dependent variables, *board_networksize* and *ceo_networksize*, measure the total number of unique connections that board members and the CEO respectively have with external entities, reflecting the breadth of their professional networks. The regression model employs robust standard errors and includes fixed effects for industry and year to ensure the reliability and contextual accuracy of the estimates. Significance levels are denoted by asterisks, where *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Further details on the construction of variables and the sample used are provided in Appendix Table A1.

VARIABLES	board_networksize (1)	ceo_networksize (2)
weighted_strength	18.80***	23.84***
	(14.79)	(12.18)
ln_mc_lag	269.9***	266.9***
	(106.5)	(69.76)
leverage_lag	192.9***	135.9***
	(10.49)	(4.318)
ROA_lag	-274.1***	-343.3***
	(-18.73)	(-15.15)
cashholding_lag	397.0***	287.7***
	(19.00)	(7.985)
ln_firm_age	18.35***	71.06***
	(3.239)	(7.440)
Constant	-416.9***	-780.6***
	(-18.28)	(-21.43)
Observations	65,388	61,887
R-squared	0.353	0.183
Industry FE	√	√
Year FE	√	√
Robust SE	√	√

Robust t-statistics in parentheses

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

Table 5 - Multivariate Regression Analysis on Executive Educational Background

This table presents the results of multivariate regressions examining the impact of geographic density on the educational backgrounds of the board and CEO. Geographic density is defined as the weighted sum of the reciprocals of geographic distances between a focal firm and its competitors, identified by TNIC designations. The variables *board_MBA* and *board_PhD* represent the percentage of board members holding MBA and PhD degrees, respectively, while *ceo_MBA* and *ceo_PhD* are indicator variables (0 or 1) indicating whether the CEO holds an MBA or PhD degree. The regression model employs robust standard errors and includes fixed effects for industry and year to ensure the reliability and contextual accuracy of the estimates. Significance levels are denoted by asterisks, where *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Further details on the construction of variables are provided in Appendix Table A1.

VARIABLES	board_MBA	board_PhD	ceo_MBA	ceo_PhD
	(1)	(2)	(3)	(4)
weighted_strength	0.000740***	0.00167***	0.00108*	0.00249***
	(3.296)	(12.22)	(1.724)	(7.078)
ln_mc_lag	0.0164***	0.00671***	0.0332***	0.00810***
	(40.38)	(30.47)	(30.12)	(14.37)
leverage_lag	0.0585***	-0.0211***	0.0221**	-0.0319***
	(16.00)	(-10.68)	(2.302)	(-6.343)
ROA_lag	-0.00594*	-0.0344***	-0.0246***	-0.0428***
	(-1.927)	(-15.22)	(-3.163)	(-7.319)
cashholding_lag	0.0317***	0.0867***	-0.0750***	0.135***
	(7.177)	(30.12)	(-6.610)	(18.34)
ln_firm_age	-0.0154***	0.00473***	0.0250***	-0.00341**
	(-13.13)	(7.833)	(7.983)	(-2.268)
Constant	0.215***	0.00243	0.113***	0.00461
	(52.67)	(1.120)	(10.49)	(0.857)
Observations	65,390	65,390	64,305	64,305
R-squared	0.143	0.240	0.044	0.118
Industry FE	√	√	√	√
Year FE	√	√	√	√
Robust SE	√	√	√	√

Robust t-statistics in parentheses

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

Table 6 - Multivariate Regressions on the Impact of Geographic Density on Executive Compensation

This table presents the results of multivariate regressions examining the impact of geographic density on the compensation and pay of board members and CEOs. Geographic density is defined as the weighted sum of the reciprocals of geographic distances between a focal firm and its competitors, identified by TNIC designations. The dependent variables are *Compen_board* and *Pay_board*, which represent the natural logarithm of total compensation and pay of board members, respectively, and *Compen_CEO* and *Pay_CEO*, which represent the same for CEOs. The regression model employs robust standard errors and includes fixed effects for industry and year to ensure the reliability and contextual accuracy of the estimates. Significance levels are denoted by asterisks, where *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Further details on the construction of variables are provided in Appendix Table A1.

VARIABLES	Compen_board	Pay_board	Compen_CEO	Pay_CEO
	(1)	(2)	(3)	(4)
weighted_strength	0.0299***	0.0244*	0.0148***	0.0133***
	(2.655)	(1.821)	(2.786)	(3.043)
ln_mc_lag	0.335***	0.546***	0.214***	0.482***
	(11.23)	(14.80)	(19.84)	(43.55)
leverage_lag	0.0105	0.238	0.190**	0.254**
	(0.0318)	(0.546)	(2.000)	(2.196)
ROA_lag	0.0180	-0.510	-0.0330	-0.428***
	(0.0778)	(-1.606)	(-0.321)	(-3.754)
cashholding_lag	-0.642*	-0.113	-0.576***	-0.218*
	(-1.930)	(-0.263)	(-6.195)	(-1.906)
ln_firm_age	0.461***	0.485***	0.207***	0.0736***
	(5.821)	(4.988)	(8.535)	(2.763)
Constant	3.014***	2.579***	4.450***	4.426***
	(8.432)	(5.842)	(40.20)	(35.72)
Observations	1,643	1,643	6,990	6,990
R-squared	0.279	0.285	0.201	0.368
Industry FE	√	√	√	√
Year FE	√	√	√	√
Robust SE	√	√	√	√

Robust t-statistics in parentheses

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

Table 7 – Multivariate Regression Analysis on Board and CEO Characteristics and Compensation in Selected States

This table presents the results of multivariate regressions examining the impact of geographic density on various board and CEO characteristics and compensation measures within a subsample of firms located in California, New York, and Texas. Geographic density is defined as the weighted sum of the reciprocals of geographic distances between a focal firm and its competitors, identified by TNIC designations. The dependent variables include *Board_size*, the natural logarithm of the total number of board members; *ceo_chair*, an indicator variable (0 or 1) denoting whether the CEO also serves as the chairman of the board; *board_MBA* and *board_PhD*, the percentages of board members holding MBA and PhD degrees, respectively; *ceo_MBA* and *ceo_PhD*, indicator variables (0 or 1) indicating whether the CEO holds an MBA or PhD degree; and compensation measures including *Compen_board* and *Pay_board*, the total compensation and pay of board members, respectively, and *Compen_CEO* and *Pay_CEO*, the corresponding compensation measures for CEOs. The regression model employs robust standard errors and includes fixed effects for industry and year to ensure the reliability and contextual accuracy of the estimates across these specific states. Significance levels are denoted by asterisks, where *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Further details on the construction of variables and the specifics of the subsample analysis are provided in Appendix Table A1.

VARIABLES	Board_size	ceo_chair	board_MBA	board_PhD	ceo_MBA	ceo_PhD
	(1)	(2)	(3)	(4)	(5)	(6)
weighted_strength	-0.00422***	-0.000527	0.000934***	0.002685***	0.00257***	0.00269***
	(-9.330)	(-0.268)	(3.412)	(4.598)	(3.386)	(4.348)
ln_mc_lag	0.0727***	0.0251***	0.00990***	0.00719***	0.0228***	0.00717***
	(66.27)	(5.432)	(13.64)	(16.39)	(11.35)	(6.412)
leverage_lag	0.0923***	-0.0769*	0.0477***	-0.0218***	-0.00363	-0.0397***
	(8.997)	(-1.785)	(7.246)	(-5.743)	(-0.213)	(-4.186)
ROA_lag	-0.101***	0.0211	-0.000495	-0.0259***	0.000468	-0.0346***
	(-11.40)	(0.609)	(-0.103)	(-6.899)	(0.0375)	(-3.435)
cashholding_lag	-0.0830***	-0.117**	0.0326***	0.0967***	0.00764	0.132***
	(-7.896)	(-2.379)	(4.388)	(17.84)	(0.399)	(9.556)
ln_firm_age	0.0245***	0.0371**	-0.0243***	0.00759***	0.0161***	0.00418
	(7.714)	(2.575)	(-11.10)	(6.038)	(2.760)	(1.303)
Constant	1.620***	0.216***	0.285***	-4.21e-05	0.171***	0.0109
	(144.5)	(4.413)	(37.52)	(-0.00934)	(8.473)	(0.970)
Observations	19,567	3,594	19,567	19,567	19,202	19,202
R-squared	0.340	0.109	0.102	0.264	0.035	0.144
Industry FE	√	√	√	√	√	√
Year FE	√	√	√	√	√	√
Robust SE	√	√	√	√	√	√

Robust t-statistics in parentheses

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

VARIABLES	board_networksize	ceo_networksize	Compen_board	Pay_board	Compen_CEO	Pay_CEO
	(7)	(8)	(9)	(10)	(11)	(12)
weighted_strength	7.260***	12.03***	0.0351***	0.0295**	0.00348***	0.0291***
	(4.850)	(5.360)	(2.701)	(1.980)	(2.696)	(3.023)
ln_mc_lag	305.4***	316.1***	0.256***	0.440***	0.233***	0.495***
	(59.21)	(41.82)	(4.997)	(6.670)	(11.28)	(24.15)
leverage_lag	136.2***	148.8**	-0.206	-0.0898	0.256**	0.104
	(4.019)	(2.184)	(-0.319)	(-0.103)	(2.169)	(0.743)
ROA_lag	-255.6***	-354.9***	-0.0505	-0.276	-0.0106	-0.143
	(-10.16)	(-9.855)	(-0.183)	(-0.789)	(-0.0980)	(-1.120)
cashholding_lag	393.7***	401.7***	-0.748	-0.215	-0.479***	0.0839
	(10.72)	(6.296)	(-1.320)	(-0.282)	(-3.032)	(0.443)
ln_firm_age	2.602	32.87*	0.981***	1.105***	0.172***	0.0247
	(0.219)	(1.763)	(5.801)	(5.232)	(3.868)	(0.511)
Constant	-436.4***	-909.7***	2.151***	1.694*	4.455***	4.486***
	(-9.167)	(-12.40)	(2.810)	(1.764)	(22.00)	(19.61)
Observations	19,565	18,461	520	520	2,154	2,154
R-squared	0.358	0.224	0.378	0.344	0.270	0.402
Industry FE	√	√	√	√	√	√
Year FE	√	√	√	√	√	√
Robust SE	√	√	√	√	√	√

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6. Appendix Table A.1:

This table presents variable definitions and data sources.

Variable	Description	Source
Weighted_strength	Metric that quantifies geographic density of a firm's competitor network by summing the reciprocals of the Haversine-calculated distances between a focal firm and its competitors, reflecting the closeness and intensity of competitive interactions within the network.	Google & TNIC& Compustat
board_size	The natural logarithm of the total number of members serving on a company's board of directors	BoardEX
ceo_chair	An indicator variable (0 or 1) that denotes whether the CEO also serves as the chairman of the board	BoardEX
board_MBA	The percentage of board members holding an MBA degree	BoardEX
board_PhD	The percentage of board members holding a PhD degree	BoardEX
ceo_MBA	An indicator variable (0 or 1) that signifies whether the CEO holds an MBA degree	BoardEX
ceo_PhD	An indicator variable (0 or 1) that denotes whether the CEO holds a PhD degree	BoardEX
board_networksize	The total number of connections board members has with external entities, measured through professional or professional networks	BoardEX
ceo_networksize	The number of connections the CEO has with external entities, measured through professional or professional networks.	BoardEX
Compen_board	The natural logarithm of the total annual compensation for all board members combined.	BoardEX
Pay_board	The natural logarithm of the total annual pay (excluding non-cash benefits) for all board members combined.	BoardEX
Compen_CEO	The natural logarithm of the total annual compensation received by the CEO.	BoardEX
Pay_CEO	The natural logarithm of the total annual pay (excluding non-cash benefits) received by the CEO.	BoardEX

ln_mc_lag	Lag firm size of firm; natural log of market cap	Compustat
leverage_lag	Lag financial leverage of firm; total long-term debt / total asset	Compustat
cashholding_lag	Lag cash holding of firm; cash and short-term investments / total asset	Compustat
ln_firm_age	Lag firm age of firm; the natural log of the number of years since a firm's first appearance in Compustat.	Compustat

Appendix Table A.2 - Multivariate Regression Analysis on the Growth of CEO Compensation and Pay

This table presents the results of multivariate regressions examining the impact of geographic density on the growth of CEO compensation and pay. Geographic density is defined as the weighted sum of the reciprocals of geographic distances between a focal firm and its competitors, identified by TNIC designations. The dependent variables are *growth_totCompen_CEO* and *growth_totPay_CEO*, which measure the year-over-year growth in total compensation and direct pay of the CEO, respectively. The regression model employs robust standard errors and includes fixed effects for industry and year to ensure the reliability and contextual accuracy of the estimates. Significance levels are denoted by asterisks, where *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Further details on the construction of variables are provided in Appendix Table A1.

VARIABLES	growth_totCompen_CEO (1)	growth_totPay_CEO (2)
weighted_strength	-0.0271	-0.000678
	(-1.057)	(-0.0498)
ln_mc_lag	0.277	-0.0440
	(1.000)	(-1.468)
leverage_lag	2.332	0.259
	(1.541)	(1.142)
ROA_lag	0.108	-0.503
	(0.289)	(-1.011)
cashholding_lag	3.088	0.0945
	(1.144)	(0.303)
ln_firm_age	-0.172	-0.288***
	(-1.261)	(-2.983)
Constant	-2.476	1.850***
	(-0.750)	(6.025)
Observations	5,829	5,846
R-squared	0.008	0.018
Industry FE	√	√
Year FE	√	√
Robust SE	√	√

Robust t-statistics in parentheses

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