THE INTER-RELATIONSHIP AMONG CORPORATE GOVERNANCE, ARTIFICIAL INTELLIGENCE, AND INNOVATION

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OPEN ACCESS

How to cite: Gouiaa, R., & Huang, R. (2024). The inter-relationship among corporate governance, artificial intelligence, and innovation. In T. O. Sigurjonsson, A. Kostyuk, & D. Govorun (Eds.), *Corporate governance: Participants, mechanisms and performance* (pp. 92–102). Virtus Interpress. https://doi.org/10.22495/cgpmpp20

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Received: 03.11.2023
Accepted: 10.11.2023
Keywords: Corporate Governance, Ownership Concentration, Artificial Intelligence, Innovation
JEL Classification: M41, M31
DOI: 10.22495/cgpmpp20

Abstract

Although research in the field of corporate governance has been exhaustive recently many scholars have focused on the relationship between corporate governance attributes and artificial intelligence, corporate governance attributes and corporate innovation, there are few studies that combine corporate governance, artificial intelligence and corporate innovation. The main reason is due to the quantitative difficulties in measuring and distinguishing artificial intelligence activities and corporate innovation activities in enterprises. This study examines the relationships among corporate governance attributes, artificial intelligence, and corporate innovation. Adopting a new perspective, we have tried to help resolve the issue using a content analysis that integrates data from over 50 United States companies to analyze the relationship between board attributes, practice of artificial intelligence (AI) and firm innovation for the period 2018–2022. The results suggest that certain aspects of boards, such as board size, board diversity, and ownership concentration show the most significant correlations with firm AI development and innovation for overall industries, but the levels of associations also vary depending on different innovation measurements and samples considered in specific industries.

Moreover, the mediating effects of AI and innovation are examined, respectively. Lastly, we also discovered changes in the industry's attention to AI development before and after COVID-19 (2020). This research offers implications to corporate decision-makers as to how to proceed if the intent is to offer commercialized AI advancements and successful breakthrough innovations.

1. INTRODUCTION

While most previous research focused on the impact of internal governance on firm performance and value, in recent years, scholars have increasingly studied the influence of governance mechanisms on managerial innovation decisions (Tribo et al., 2007). Scholars believe that innovation efforts and outcomes depend on factors influenced by corporate governance, such as ownership structure or board composition. Ortega-Argils et al. (2005) found that highly concentrated ownership and reliance on debt financing hinder firms' investment in research and development (R&D) and do not yield favorable R&D outcomes. Asensio-López et al. (2018) argued that different internal corporate governance mechanisms may even be determining factors for firm innovation. In addition to ownership structure, the board structure also has a certain impact on firm innovation and its efficiency. Feng and Wen (2008) found a significant positive relationship between the proportion of independent directors on the board and innovation investment, the lower the proportion of independent directors, the relatively less innovation investment by the firm. It can be found that in recent years there has been a growing interest in the literature regarding the role played by boards and the characteristics of boards that are most conducive to promoting corporate innovation. However, the empirical evidence is not conclusive, and the results are sometimes contradictory. This is mainly because previous studies focused on a single variable related to the board, the variables were defined in different ways, or innovation was not considered from both input and output dimensions. Therefore, it is necessary to integrate all corporate governance elements that may have an impact on innovation activities.

Previous studies also proved that the effect of corporate governance on artificial intelligence existed, and there is an inherent connection mechanism between the two. However, the current research on this impact mechanism is still in the exploratory stage, few scholars have researched this aspect, and academics have not formed a unified view about the measurement of artificial intelligence. Our study will also analyze the empirical mechanism of corporate governance affecting artificial intelligence and test the impact in terms of specific governance elements.

Moreover, our findings also highlight the existence of the mediating effect of artificial intelligence (AI) or innovation. Most of the previous

literature analyzed AI and innovation separately. By observing the variables measured by previous scholars, we found that the measurement indicators of AI and innovation are relatively fixed and have undetermined overlaps. Therefore, it can be inferred that due to the inefficiency in quantitatively distinguishing the two variables, scholars have not yet analyzed the two in a unified manner. Subsequently, we innovatively used the frequency of text words related to the two, extracted from financial reports as an indicator to measure the difference in the company's focus on AI development and innovation activities, which is also combined with traditional measurements (Coluccia et al., 2020), thereby confirming the effect and difference in the role of the two as mediating variables.

2. THEORETICAL BACKGROUND AND RESEARCH HYPOTHESES

Based on the above discussion, the present study proposes and tests the following hypotheses.

Existing literature largely suggests that an excessively large board size has a negative impact on corporate innovation. In contrast, a smaller board size leads to more corporate innovation, ultimately resulting in sustainable development (Chindasombatcharoen et al., 2022).

H1: There is a negative correlation between board size and AI practice or innovation efforts.

Some scholars argue that independent board members are essential for company development as they can provide resources for innovation activities (Mi Choi et al., 2012). Additionally, studies have found that higher board independence positively influences an increase in patent numbers for companies, stimulating their innovative spirit (Coelho, 2015).

H2: Board independence is positively related to corporate innovation decisions and AI-related activities.

Diverse board compositions in terms of gender, age, etc., have a positive impact on various forms of innovation. As the decision-making center of a company, diverse boards offer a broader range of viewpoints and perspectives, enhancing advisory capabilities and supporting exploratory innovation (Zhu et al., 2020).

H3: Board diversity is positively correlated with corporate innovation decisions and AI-related activities.

Ownership concentration and the identity of investors holding substantial ownership have an impact on innovation (Lee, 2005). The distribution of ownership in a company determines the control that decision-makers have over resource allocation and the incentives they must invest in innovation (Miozzo & Dewick, 2002; Aghion et al., 2009).

H4: Concentrated ownership is negatively related to artificial intelligence development and innovative activities.

Italian listed companies operating in the industries and the frequency of meetings held by the board assume a relevant role in supporting the investments in innovation (Martini et al., 2012). Board meeting frequency was put up to play a significant impact on eco-innovation as one significant demographic factor (Zaman et al., 2023).

H5: Board meeting frequency is positively related to artificial intelligence development and innovative progress.

Innovation performance could be promoted by corporate social responsibility via employee involvement and supplier collaboration (Zho et al., 2020).

H6: Corporate social responsibility has a positive correlation with AI and innovation within companies.

Chief executive officer (CEO) compensation has a significant regulating effect on the company's innovation capabilities, and the establishment of a compensation committee has a significant constraining effect on CEO compensation (Akram et al., 2022).

H7: Nomination committee and compensation committee are positively related to AI and innovation development within a company.

Artificial intelligence is a discipline centered around knowledge, encompassing the representation, acquisition, and utilization of knowledge. The application of AI in business model innovation has been increasing (Reim et al., 2020), reshaping the way companies innovate and the nature of innovations.

H8: AI plays a positive role in corporate governance and innovation efforts, so as for innovation.

3. RESEARCH METHODOLOGY

3.1. Sample description and data

To test our hypotheses, we analyze annual reports and other financial statements from 2018 to 2022 of the American companies listed on the Nasdaq Composite index of our sample. These companies are from 5 different industries according to the classification of NAICS. Companies with missing observations and outliers (based on 1st and 99th percentiles) were excluded. After matching and examining the data from the different sources the final sample consisted of 5400 observations corresponding to 60 companies listed on the Nasdaq Composite Index from 2018 to 2022.

Data for this study was collected from different databases. Firstly, accounting and financial data were manually extracted and collected from the EDGAR database. Secondly, data regarding board characteristics, ownership information and environmental, social, and corporate governance (ESG) from 2018 to 2022 were collected from the Eikon database, with our definition of concentrated ownership structure when the top-20 shareholders accounted for over 45% shares.

Lastly, annual reports were downloaded from the SEDAR online database, and analyzed by our Python code. This study examines the relation between corporate governance systems and artificial intelligence, innovation. More specifically, we analyze how corporate governance attributes, and particularly board characteristics, can affect AI, innovation efforts in the context of American listed companies.

Furthermore, due to the widespread adoption of AI in recent years, with frequent mentions in annual reports, we calculated a company's AI application index through text analysis. To be more specific, we construct an AI-related vocabulary and use Python to automatically extract and count words that share similar attributes, with common characteristics of word expressions considered. This process involves the extraction of about 20 commonly used AI-related terms based on shared attributes, forming the sub-dictionary for this study. Included terms like big data, intelligence, authentication, automation, integration, digitization, virtual, algorithm, cloud computing, blockchain, machine learning, integration, etc. Due to the broad and general nature of these terms, expressions not relevant to AI are manually excluded. Finally, the word frequencies of each phrase are summed to obtain the total word frequency, which is then considered to represent the AI application index for publicly listed companies. Moreover, the same procedures are also applied to innovation measurement as one main variable of the innovation index.

We utilize the content-analysis research method, using multiple regression analysis to examine our hypotheses. More specifically, we incorporate corporate governance variables, ESG score and ownership structure characteristics into different regression models, to analyze the overall impact on AI practice and innovation. Additionally, based on existing studies (He & Tian, 2013; Chen & Wang, 2014), we control for other determining factors of innovation, including firm size and leverage. Apart from that, we establish another model to examine the mediation effect of AI and innovation indexes separately, aiming to prove the mediating effect played by one specific variable to another.

3.2. Corporate social responsibility index: ESG score

Since the ESG score is easy to access, it is often used as a proxy for corporate sustainability performance (Drempetic et al., 2020). There are three categories of ESG indicators in the Thomson Reuters EIKON database: ESG score, ESG controversies and ESG combined score. We choose the ESG score as our measurement, which is based on publicly available data in ten thematic areas. To make the ESG score easier to conduct analysis, we code it into 1–12 according to the ESG score from D- to A+ in Eikon database.

3.3. Measures of explanatory variables

In Table 1, we present the description of board characteristics measures used in this study. In addition to control variables, Table 1 presents the description of AI and innovation measures.

Table 1. Measures of board characteristics and control variables

Variables	***Description***
BS	Board size: Number of directors comprising the board of directors
BD	Board diversity: Percentage of female directors on the board
BM	Board meeting: Number of meetings held by the board of directors in a calendar year
ESG	ESG scores: Comprehensive scores in environmental, social and governance to evaluate social responsibility
BI	Board independence: Percentage of independent directors on the board
OC	Ownership concentration: Measured by dichotomous variable
C1	Nomination committee: Present whether the company has a nomination committee
C2	Compensation committee: Present whether the company has a compensation committee
MAI	Mere AI: Number of words directly related to AI in annual report
R1	Ratio 1: Percentage of number of direct AI words to pages of annual report
AI	AI: Number of words broadly related to AI in annual report
R2	Ratio 2: Percentage of number of overall words to pages of annual report
INN	Innovation: Number of words related to innovation in annual report
R3	Ratio 3: Percentage of number of innovation words to pages of annual report
R&D	R&D investment: Number of investments put into research and development
TA	Total assets: Logarithm of the total assets
Lev	Leverage: Total debts/total assets
IND	Industry: Measured by five dichotomous variables for the 5 major industries under the classification of NAICS: *IND1* (manufacture), *IND2* (information), *IND3* (credit), *IND4* (insurance), *IND5* (professional service)

4. RESULTS ANALYSIS

4.1. Descriptive results

The results presented in Table 2 reveal that the average board size is around 6 directors and ranges from 2 to 12 directors. An in-depth search into board diversity indicates that, among five industries in our research, the mean proportion of women on board is 28%, with the lowest percentage of approximately 5% and the maximum could be found up to 58% of board directors are made up of women. These results also show that boards of United States companies meet at least 1 time during a year, up to 32 times a year, with an average of 10 meetings per year. The results reveal that the ESG scores vary from 2 to 12, in accordance with their D- to A+ level, with an average of 8 points. In terms of board independence, approximately 84% of directors are independent according

to the requirements of New York Stock Exchange (NYSE). About 30% of the sample companies are considered to have a concentrated ownership structure, and 78% of firms set a Nomination committee, while almost 90% of firms have a compensation committee. In the detailed search into the industry by industry, we found the credit and insurance industries are the two which own the highest record of board size, with 13 and 14 directors on average respectively, and the credit industry also has the largest average ratio of women on board compared to other industries, around 33%.

4.2. Regression results

For our regression results, our first two models examined the effect of board characteristics and composition on their emphasis on artificial intelligence and innovative activities. The results show that ownership concentration has a negative impact on carrying out both artificial intelligence-related and innovation index, which shows that the more concentrated the ownership, the more shareholders tend to be conservative and less willing to carry out innovative activities. And our control variables of *IND2*, *IND3*, *IND4* also reveal negative influence. By contrast, *IND1*, *IND5* defined as manufacturing and professional services shows a strong positive impact on referring two dependent variables. Meanwhile, the result of board size shows that the more directors on a board, the less likely for a company to put up innovation, suggesting that boards with fewer directors will be more willing to take innovation-related activities, confirming our first research hypothesis (*H1*).

In a more detailed analysis of individual industries, we found that there are significant differences in the corporate governance variables that play a significant role in different industries, which also show satisfactory statistical results with significant statistical coefficients. Specifically, board independence has a significant positive impact on AI and innovation in manufacturing companies; however, for the information industry, the proportion of independent directors has a significant negative impact on AI and innovation. Looking at the credit industry, board meeting has a significant positive effect on AI, and ESG score has a significant positive effect on innovation. As for the insurance carriers, ESG scores and the establishment of two committees have a significant positive impact on innovation, while board size and board diversity have a significant negative effect on AI. Finally, in the service industry, R square is the highest (0.83). Interestingly, *committee 1* and ESG score have a significant negative impact on AI, though board meeting has a significant positive impact on AI. However, other significant variables were observed in this innovation index: board size and board diversity have a significant positive effect on innovation, which is exactly the opposite of the insurance industry.

R&D investment, as the observed innovative variable particularly for *IND1* and *IND5*, also shows satisfactory statistical significance. In the *IND1* manufacturing industry, board size, board independence and concentrated ownership structure have a significant negative effect on R&D investment, while board diversity, *committee 1*, and *committee 2* have a significant positive effect. *IND5* service industry also shows that the concentrated ownership structure is not conducive to the growth of R&D investment and has a negative effect.

Table 2. Regression results for AI and innovation (in total)

Variables	*AI*			*Innovation*		
	Standardized β	***t***	***Sig.***	***Standardized β***	***t***	***Sig.***
BS	-0.063	-0.819	0.414	-0.182	-1.826	0.069*
BD	-0.087	-1.520	0.130	0.002	0.020	0.984
BM	0.072	1.169	0.244	-0.027	-0.341	0.733
ESG	-0.154	-1.640	0.103	0.130	1.069	0.287
BI	0.047	0.688	0.492	0.107	1.206	0.229
OC	-0.277	-4.244	< 0.001***	-0.216	-2.566	0.011**
C1	-0.121	-2.118	0.035	0.111	1.507	0.133
C2	0.050	0.836	0.404	0.109	1.403	0.162
TA	0.150	1.558	0.121	0.180	1.440	0.151
Lev	0.014	0.216	0.830	0.147	1.746	0.082*
IND2	-0.420	-5.494	< 0.001***	-0.213	-2.151	0.033**
IND3	-0.301	-3.854	< 0.001***	-0.185	-1.834	0.068*
IND4	-0.480	-6.040	< 0.001***	-0.088	-0.854	0.394
IND5	0.351	6.185	< 0.001***	0.131	1.783	0.076*
	R square = 0.535			R square = 0.222		

*Note: ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.*

4.3. Mediating regression results

In our first mediation regression model, we test the mediation role of AI between corporate governance and innovation efforts. The results show that both the ESG score and *committee 1* have a more satisfactory positive impact on innovation under the mediation of AI practice. This intermediary role still exists in the specific industry analysis; therefore, we infer that the importance of AI has a significantly enhanced intermediary role in the practice of corporate governance and innovation. The second regression model of intermediary function tests the intermediary effect of innovation, and the results show a higher explanatory degree than the former, and the negative effects of board diversity, ESG score, ownership structure and *committee 1* are significantly enhanced. To conclude, the role of innovation efforts as an intermediary variable has also been confirmed.

5. CONCLUSION

Corporate governance elements such as board characteristics and shareholder structure play a significant and important role. The results of this study verify the important impact of board characteristics and ownership structure, especially the importance of individual indicators such as board structure on the company's investment in AI development, innovation, and R&D investment. For different industry characteristics, the stronger the individual board characteristics, the more attention it will pay to the development of AI, and the stronger its promotion effect on innovative activities. Vice versa, the more investment in innovation, the stronger the joint effect on AI development.

The research results help to enrich the literature in the field of corporate governance and demonstrate the importance of key features of corporate governance in promoting AI development and innovation in the digital era. This study determines a research structure method with text research as the core, supplemented by traditional variables, and the effectiveness is cross-checked through the successful extraction of word frequency from lots of annual reports and the results of different variables of the same indicator. Corporate governance has more significant variables in the manufacturing and information technology service industries. More attention is paid to the development of artificial intelligence and more money is invested in R&D and innovation activities.

This study shows that an overly concentrated ownership structure and a high number of directors have a negative impact on innovation progress and the development of AI in multiple industries. There are differences in the specific variables that affect AI and innovation activities in different industries. Therefore, companies are encouraged to adapt to local conditions and choose corporate governance improvement methods suitable for their own industry characteristics to adapt to the trend in the context of big data and artificial intelligence transformation and promote the company's progress in digitalization, intelligent upgradation, and innovative sustainable prosperity.

This study includes the main characteristics of the main corporate board and shareholder structures, but there are other characteristics that were not considered. Therefore, further research in the future will incorporate other corporate governance elements such as major shareholder types, board tenure, etc. into combined discussions. We will also conduct country comparisons, such as comparing companies in the United States and Canada, to explore the similarities and differences in the impact of corporate governance factors on AI and innovation between countries.

REFERENCES

1. Aghion, P., Van Reenen, J., & Zingales, L. (2009). *Innovation and institutional ownership* (NBER Working Paper No. 14769). National Bureau of Economic Research. https://doi.org/10.3386/w14769
2. Akram, H., Azam, N., Farooq, M. U., Ahad, A., & Saadat, U. (2022). Impact of CEO compensation and CEO power on firms' innovation moderating role of ownership structure. *Jurnal Aplikasi Manajemen, Ekonomi dan Bisnis*, *6*(2), 61–73. https://doi.org/10.51263/jameb.v6i2.146
3. Asensio-López, D., Cabeza-García, L., & González-Álvarez, N. (2018). Corporate governance and innovation: A theoretical review. *European Journal of Management and Business Economics*, *28*(3), 266–284. https://doi.org/10.1108/EJMBE-05-2018-0056
4. Chen, J., & Wang, T. (2014). *Financial leverage and profitability of SMEs: An empirical research*. https://www.researchgate.net/publication/372627417_Financial_leverage_and_profitability_of_SMEs_An_empirical_research
5. Chindasombatcharoen, P., Chatjuthamard, P., Jiraporn, P., & Treepongkaruna, S. (2022). Achieving sustainable development goals through board size and innovation. *Sustainable Development*, *30*(4), 664–677. https://doi.org/10.1002/sd.2264
6. Coelho, M. C. C. (2015). *Board independence and innovation* [Doctoral dissertation, Nova School of Business and Economics]. Nova School of Business and Economics Repository. https://run.unl.pt/handle/10362/15344
7. Coluccia, D., Dabić, M., Del Giudice, M., Fontana, S., & Solimene, S. (2020). R&D innovation indicator and its effects on the market. An empirical assessment from a financial perspective. *Journal of Business Research*, *119*, 259–271. https://doi.org/10.1016/j.jbusres.2019.04.015
8. Drempetic, S., Klein, C., & Zwergel, B. (2020). The influence of firm size on the ESG score: Corporate sustainability ratings under review. *Journal of Business Ethics*, *167*, 333–360. https://doi.org/10.1007/s10551-019-04164-1
9. Feng, G. F., & Wen, J. (2008). Empirical analysis of the relationship between Chinese listed company governance and corporate technological innovation. *China Industrial Economics, 7*, 91–101.
10. He, J., & Tian, X. (2013). The dark side of analyst coverage: The case of innovation. *Journal of Financial Economics, 109*(3), 856–878. https://doi.org/10.1016/j.jfineco.2013.04.001
11. Lee, P. M. (2005). A comparison of ownership structures and innovations of US and Japanese firms. *Managerial and Decision Economics, 26*(1), 39–50. https://doi.org/10.1002/mde.1188
12. Martini, S. B., Corvino, A., & Rigolini, A. (2012). Board diversity and structure: What implications for investments in innovation? Empirical evidence from Italian context. *Corporate Ownership & Control*, *10*(1), 9–25. https://doi.org/10.22495/cocv10i1art1
13. Mi Choi, H., Sul, W., & Kee Min, S. (2012). Foreign board membership and firm value in Korea. *Management Decision, 50*(2), 207–233. https://doi.org/10.1108/00251741211203533
14. Miozzo, M., & Dewick, P. (2002). Building competitive advantage: Innovation and corporate governance in European construction. *Research Policy, 31*(6), 989–1008. https://doi.org/10.1016/S0048-7333(01)00173-1
15. Ortega-Argiles, R., Moreno, R., & Caralt, J. S. (2005). Ownership structure and innovation: Is there a real link? *The Annals of Regional Science*, *39*, 637–662. https://doi.org/10.1007/s00168-005-0026-6

16. Paruzel, A., Schmidt, L., & Maier, G. W. (2023). Corporate social responsibility and employee innovative behaviors: A meta-analysis. *Journal of Cleaner Production*, *393*, Article 136189. https://doi.org/10.1016/j.jclepro.2023.136189
17. Reim, W., Åström, J., & Eriksson, O. (2020). Implementation of artificial intelligence (AI): A roadmap for business model innovation. *AI, 1*(2), 180–191. https://doi.org/10.3390/ai1020011
18. Tribo, J. A., Berrone, P., & Surroca, J. (2007). Do the type and number of blockholders influence R&D investments? New evidence from Spain. *Corporate Governance: An International Review, 15*(5), 828–842. https://doi.org/10.1111/j.1467-8683.2007.00622.x
19. Weian, L., Chen, H., Guangyao, C., Minna, Z., & Qiankun, M. (2019). Forty years of corporate governance research: A review and agenda. *Foreign Economics & Management*, *41*(12), 161–185. https://qks.sufe.edu.cn/J/WJGL/Article/Details/a9c74203-0718-4697-9a1d-186ea31b055d
20. Zaman, R., Asiaei, K., Nadeem, M., Malik, I., & Arif, M. (2023). Board demographic, structural diversity, and eco-innovation: International evidence. *Corporate Governance: An International Review*. Advance online publication. https://doi.org/10.1111/corg.12545
21. Zhou, H., Wang, Q., & Zhao, X. (2020). Corporate social responsibility and innovation: A comparative study. *Industrial Management & Data Systems, 120*(5), 863–882. https://doi.org/10.1108/IMDS-09-2019-0493
22. Zhu, Y., Li, R., & Liu, W. (2020). Research on the influence of diversified backgrounds of board members on the innovation output of enterprises: An analysis based on the effectiveness of internal control. *Journal of South China Normal University (Natural Science Edition)*, *52*(4), 120–128. http://journal-n.scnu.edu.cn/cn/article/doi/10.6054/j.jscnun.2020070?viewType=HTML