THE COMPARISON BETWEEN THE UNITED STATES AND CANADA: FINDINGS FROM INTER-RELATIONSHIP AMONG CORPORATE GOVERNANCE, ARTIFICIAL INTELLIGENCE, AND INNOVATION

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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 (AI), corporate governance attributes, and corporate innovation, few studies combine corporate governance, AI, and corporate innovation. The main reason is due to the quantitative difficulties in measuring and distinguishing AI activities and corporate innovation activities in enterprises. This study examines the relationships among corporate governance attributes, AI, and corporate innovation in the context of the United States and Canada. Adopting a new perspective, we have tried to help resolve the issue using a content analysis that integrates data from over 100 companies that trade on National Association of Securities Dealers Automated Quotations (NASDAQ) and TSX to analyze the relationship between board attributes, practice of AI and firm innovation for the time 2018–2022. The results suggest that particular

aspects of boards, such as board size, board diversity, and ownership concentration show 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. (2019) 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 (AI) 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 of the measurement of AI. 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 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 AI 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 investments in innovation (Bianchi 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 AI 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.

AI 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. FURTHER 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 and Canadian companies listed on the TSX 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 60 American companies and 50 Canadian companies listed on the NASDAQ Composite Index, TSX 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 and Eikon database. Secondly, data regarding board characteristics, ownership information, and environmental, social, and

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% of 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 AI, 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 chose 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 the Eikon database.

3.3. Measures of explanatory variables

Table 1 presents the different measures of board characteristics, board committees, ESG scores, AI, innovation, and control variables. These measures and variables will be used to test our research hypotheses and to check the interactions between corporate governance, innovation, and AI.

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 an 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 five 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 descriptive results reveal that the average board size is around 11 directors in both countries and ranges from 5 to 22 directors. An in-depth search into board diversity indicates that, among the five industries in our research, the mean proportion of women on board in the cases of Canada is around 32%, which is higher than 28% in the United States. The maximum figure could be found up to 67% of board directors are made up of women in Canada. 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 the U.S. Securities and Exchange Act. Almost 70% of firms in this sample have a concentrated ownership structure, 77% of firms own nomination committees, and 89% of firms have compensation committees. 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 number 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 AI and innovative activities. The data of American companies show higher explanatory power in our first model, with the R-square of 53.5%, while Canada shows higher explanatory power in our second model with the R-square of 48.7%. The results show that ownership concentration has a negative impact on carrying out both AI-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*, and *IND4* also reveal negative influence. By contrast, *IND1* and *IND5* defined as manufacturing and professional services show 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, confirms 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, the 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.

4.3. Mediating regression results

Our two mediation models respectively test the impact of AI as an intermediary variable on the relationship between corporate governance and innovation in the manufacturing and service industries and are applied to both countries. The results show that under these models, the mediating effect of AI shows significant effects in the American manufacturing industry and the Canadian professional industry.

It is worth noting that in the discussion of the intermediary mechanism of these two industries, ownership concentration always has a significant negative impact in the United States, while ESG scores positively impact innovation in Canadian companies. For specific manufacturing industry analysis, ownership structure could positively impact innovative practices in both countries. Moreover, board size and nomination committee could lead to more effort in innovation and relative investment in innovative practices in the context of the United States. In terms of the professional industry, it is found that board size has a significantly positive impact on innovation in both countries.

5. CONCLUSION

Corporate governance elements such as board characteristics and shareholder structure play a significant 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.

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, and this conclusion could be found in both the United States and Canada. There are apparent differences in the specific variables that affect AI and innovation activities in different industries. Therefore, companies are encouraged to adapt to their local conditions and choose corporate governance improvement methods suitable for their own industry characteristics to better adapt to the trend in the context of big data and AI transformation, thus promoting the company's performance in digitalization, intelligent upgradation, and innovative sustainable prosperity.

Our first contribution to industries is to provide statistical support to board directors and shareholders to reconsider board activities and structure, which could provide insights to facilitate the improvement and enhance efficiency of corporate governance. Moreover, further analysis also presents the financial market and relative authorities with the potential impact of AI on governance characteristics, aiming to help modify or upgrade supervising policies according to the dynamic changing technology.

Taking the 5-year data into analysis, we also found that AI development in various industries experienced a short-term surge from 2020 to 2021, and gradually fell back to the original average after 2021. Therefore, we speculate that COVID-19 would promote innovation activities and the application of artificial intelligence in various industries. However, this needs to be further explored and confirmed by subsequent research.

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 explore the similarities and differences in the impact of corporate governance factors on AI and innovation between countries.

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