THE ROLE OF NON-EXECUTIVE TECHNICAL DIRECTORS IN FOSTERING COMPANY INNOVATION

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ABSTRACT
The long-term prosperity of a business depends heavily on innovation. Although many businesses have in-house R&D departments, the contribution of non-executive technical directors to innovation is often disregarded. The purpose of this study is to understand better the contribution of non-executive technical directors to corporate innovation.
Semi-structured interviews with non-executive technical directors of different organizations were employed as a qualitative study strategy to collect data. The data was analyzed using a thematic approach to isolate common threads.
According to the report, non-executive technical directors encourage creativity and new business ideas. The insights and technical knowledge they bring to the boardroom support the company's innovation strategy. Non-executive technical directors also serve as a link between the company's technical personnel and the board, ensuring that innovation projects are in line with the company's overall strategy.
A company's innovation ecosystem must include non-executive technical directors. Their capacity to bridge the gap between the technical and business sides of the organization, as well as their technical experience and strategic thinking, make them invaluable to the company's innovation initiatives. Businesses that place a high priority on the position of non-executive technical directors in their strategic plan are more likely to have long-term success and development.

KEYWORDS: Non-Executive Technical Directors; Propensity Score Matching (PSM); Quantitative Analysis; Innovation Strategies Board Composition and Innovation; Company Growth Metrics; Statistical Methods in Corporate Governance; Empirical Research in Business Innovation; Organizational Leadership and Technology; Strategic Decision-Making.

RESUMEN
La prosperidad a largo plazo de una empresa depende en gran medida de la innovación. Aunque muchas empresas tienen departamentos internos de investigación y desarrollo, a menudo se pasa por alto la contribución de los directores técnicos no ejecutivos a la innovación. El objetivo de este estudio es comprender mejor la contribución de los directores técnicos no ejecutivos a la innovación empresarial.
Se emplearon entrevistas semiestructuradas con directores técnicos no ejecutivos de diferentes organizaciones, como estrategia de estudio cualitativo para datos. Los datos se analizaron utilizando un enfoque temático para aislar los hilos comunes.
Según el informe, los directores técnicos no ejecutivos fomentan la creatividad y las nuevas ideas de negocio. Los conocimientos y conocimientos técnicos que aportan a la sala de juntas respaldan la estrategia de innovación de la empresa. Los directores técnicos no ejecutivos también sirven de enlace entre el personal técnico de la compañía y el consejo de administración, asegurando que los proyectos de innovación estén alineados con la estrategia global de la compañía.
El ecosistema de innovación de una empresa debe incluir directores técnicos no ejecutivos. Su capacidad para cerrar la brecha entre los aspectos técnicos y comerciales de la organización, así como su experiencia técnica y pensamiento estratégico, los hacen invaluables para las iniciativas de innovación de la empresa. Las empresas que otorgan una alta prioridad a la posición de directores técnicos no ejecutivos en su plan estratégico tienen más probabilidades de tener éxito y desarrollo a largo plazo.

PALABRAS CLAVE: Directores Técnicos No Ejecutivos; Emparejamiento de la puntuación de propensión (PSM); Análisis cuantitativo; Composición del Consejo de Estrategias de Innovación e Innovación; Métricas de crecimiento de la empresa; Métodos Estadísticos en Gobierno Corporativo; Investigación Empírica en Innovación Empresarial; Liderazgo Organizacional y Tecnología; Toma de decisiones estratégicas.

1. INTRODUCTION

Every business that wants to thrive and expand must prioritize innovation as a top priority. It enables businesses to maintain their competitive edge in a market that is constantly shifting and assists them in adjusting to new possibilities and challenges. However, promoting innovation inside a corporation is a complex undertaking involving elements including leadership, technology, strategy, and experience. Including non-executive technical directors on a company's board of directors is one issue that is sometimes underestimated yet has the potential to influence innovation significantly.
Non-executive technical directors are persons with technical competence who are not engaged in the day-to-day operations of a corporation. They offer a fresh point of view to the boardroom and specialized knowledge and ideas from the technological world that may contribute to developing the company's innovation strategy. In addition, they serve as a link between the technical team of the firm and the board, facilitating communication between the two parties and ensuring that innovation projects align with the organization's overall strategy [1].
The focus of this study is on how non-executive technical directors might help propel innovation inside organizations. This study aims to identify how non-executive technical directors in various companies can contribute to innovation

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efforts and assist companies in remaining competitive in a market that is rapidly changing by examining the experiences of non-executive technical directors in various companies.

The potential influence that this study might have on businesses and their capacity for innovation is what gives it its relevance. Even though the significance of innovation is generally acknowledged, the role that non-executive technical directors play in encouraging innovative thinking is often disregarded. This study can help companies recognize the importance of including non-executive technical directors on their boards by highlighting the value these individuals can bring to a company's innovation strategy. This value can be brought to light by highlighting the findings of this study.

Prior studies have investigated how board composition and diversity may play a role in fostering innovation; however, more attention must be paid to the role that non-executive technical directors play in this process. One study by Wang et al. [2] indicated that board diversity, mainly including non-executive technical directors, was positively connected to innovation in Chinese enterprises. Nevertheless, further study is required to investigate how non-executive technical directors might contribute to innovation initiatives.

There are also a number of competing and controversial views on the function of non-executive technical directors in the process of fostering innovation. For instance, some contend that more than having technical competence is required to encourage innovation and that a more comprehensive understanding of business is required [3]. Others say that non-executive technical directors may lead to friction and tension inside the boardroom and that technical decisions should be left to the company's technical personnel [4]. These opposing points of view bring to light the need to do more studies to investigate the possible advantages and disadvantages of putting non-executive technical directors on the board of directors of a corporation.

This study's primary objective is to determine how non-executive technical directors contribute to attempts to innovate and encourage long-term success and development inside firms. This study will collect data from non-executive technical directors at a variety of firms in order to uncover the essential themes and elements that contribute to their effectiveness in promoting innovation. The data will be gathered via qualitative study methodologies.

Innovation is a critical component of a company's long-term performance, and the role of non-executive technical directors in supporting innovation should be more frequently addressed. This study aims to investigate how non-executive technical directors contribute to innovation initiatives and assist organizations in remaining competitive in a constantly evolving market. By identifying the characteristics contributing to their success, this study may help firms understand the value that non-executive technical directors can provide to their innovation strategy and make educated choices regarding board composition.

The aim of this paper is to investigate the contribution of non-executive technical directors to corporate innovation. While many businesses have their own study and development divisions, non-executive technical directors' contributions to innovation are sometimes disregarded. The purpose of this study is to learn more about how non-executive technical directors may help firms foster innovation and originality.

2. PROBLEM STATEMENT

The function of innovation is essential for a company's long-term success and expansion. Even though most businesses have in-house R&D departments, the role of non-executive technical directors in encouraging innovation should be more valued. Consequently, the issue statement of this article is to better understand the function of non-executive technical directors in supporting and nurturing innovation inside a corporation. This problem statement aims to investigate how non-executive technical directors might help strengthen a company's innovation ecosystem by facilitating communication between the company's technical and business divisions. Non-executive technical directors' contributions to a company's performance and development may be maximized if management fully grasps their function.

3. LITERATURE REVIEW

Business success relies on innovation, defined as introducing novel ideas, goods, services, or processes to enhance the worth of an established enterprise [5]. It enhances the visibility of firms in the market, improves operational effectiveness, reduces costs, and creates opportunities for additional revenue streams. Innovation manifests in several forms, from minor adjustments to existing products to groundbreaking advancements that disrupt whole sectors. Governments and corporations worldwide are aggressively promoting innovation due to its potential beneficial economic impact, such as job generation [4]. However, other barriers impede innovation, including the potential for failure and the need to balance risk, profitability, and risk management. The repercussions are often inconspicuous or immediate, making quantifying its impact arduous. Despite these challenges, innovation is crucial for a company's relevance and competitive edge [6]. Therefore, it is evident that companies should strive to foster innovation.

A strong association exists between an organisation's capacity to innovate and the diversity and composition of its board of directors. A diverse panel, including a wide variety of experiences and opinions, will likely lead to increased research and development (R&D) efforts, product launches, and financial success [7, 8]. Including diverse board members, including non-executive directors, may stimulate innovative thinking due to the introduction of novel viewpoints and guidance they provide [9, 10]. However, there needs to be more knowledge on how non-executive technical directors might promote an atmosphere favourable to innovation [11]. Their familiarity with the company's technical staff and expertise in boardroom communication may facilitate the board's adherence to its long-term goals.

There is disagreement over the effectiveness of non-executive technical directors in fostering innovation. Some argue that a comprehensive comprehension of the organisation has more significance [3, 12]. It underscores the need to examine the advantages of including technical non-executive members on corporate boards.

Non-executive directors who are not actively involved in the firm's day-to-day operations may provide impartial advice and new perspectives on long-term strategy [4, 9]. Their role in fostering innovation is closely tied to their ability to provide unbiased and objective suggestions. A board of individuals with diverse backgrounds and perspectives is more inclined to provide innovative and feasible solutions to problems[7, 8]. The presence of diversity in the boardroom is an additional crucial component. Other research is required to examine the potential benefits and drawbacks of including non-executive technical directors on corporate boards since the precise role of these directors in promoting innovation still needs to be determined.

Non-executive technical directors provide vital insights into boardroom dynamics by facilitating collaboration between technical personnel and executive leadership [11]. Their expertise in technical matters has significance, but opinions vary on their effectiveness in nurturing creativity. Some emphasise the importance of identifying emerging technological advancements, while others advocate for a comprehensive comprehension of business [3, 12]. Additional research is required to comprehend their impact on innovation outcomes and financial performance, as their role in driving innovation becomes increasingly critical in the face of advancing technology and complex industries.

An area of disagreement is about the effectiveness of non-executive technical directors in fostering innovation. Different viewpoints exist about the sufficiency of technical knowledge without a strong understanding of business operations [11] and the significance of boardroom conflicts [10, 13]. Additional research is required to explore the advantages and disadvantages of including individuals with diverse views on corporate boards due to their wide range of viewpoints. Non-executive technical directors can significantly influence a company's operations, especially given the increasing intricacy of the technological challenges they must address despite potential obstacles.

Prior research examining the role of non-executive technical directors in innovation has shown a favourable correlation between board diversity and creativity [2, 3]. However, a more comprehensive analysis is necessary to understand their purpose and impact in different situations completely. To effectively harness their capacity for innovation, the selection or appointment of non-executive technical directors should be made with due consideration [14].

4. HYPOTHESIS DEVELOPMENT

The article examines the influence of non-executive technical directors on firm innovation by presenting three hypotheses, each substantiated by a distinct statistical model.

Hypothesis 1 (H1) suggests that having non-executive technical directors on a company's board is linked to a higher level of strategic planning for innovation and developing a long-term innovation strategy. To assess this, we utilise a regression model in which the level of strategic planning for innovation serves as the dependent variable. In contrast, the presence of non-executive technical directors (represented by a binary variable: 0 = absent, 1 = present) acts as the primary independent variable [5]. Additionally, we include control variables such as company size and industry type. The equation represents the model:

$$StrategicPlanningi = \beta_0 + \beta_1 \times NonExecTech_i + \sum \beta_{control} \times ControlVariables_i + \epsilon_i$$

Hypothesis 2 (H2) posits that organisations that have non-executive technical directors are more likely to allocate resources towards research and development (R&D) and the introduction of new goods and services. The hypothesis will be examined by employing two distinct regression models: one for R&D investment and another for the new product/service introduction rate. The independent variable in both models will be the presence of non-executive technical directors [6]. Additional controls, such as industry R&D intensity, will be included to account for other factors. The equations that relate to this are as follows:

$$RnDInvestment_i = \beta_0 + \beta_1 \times NonExecTech_i + \sum \beta_{control} \times ControlVariables_i + \epsilon_i$$

$$NewProductRate_i = \beta_0 + \beta_1 \times NonExecTech_i + \sum \beta_{control} \times ControlVariables_i + \epsilon_i$$

Hypothesis 3 (H3) proposes a direct correlation between board diversity, namely non-executive technical directors' presence and a company's financial success. The hypothesis model incorporates a financial performance measure as the dependent variable, with the board diversity index and the presence of non-executive technical directors as independent factors [7]. Additionally, control variables such as firm size and market capitalization are included. The formulation of the model is as follows:

$$FinancialPerformance_i = \beta_0 + \beta_1 \times BoardDiversityIndex_i + \beta_2 \times NonExecTech_i + \sum \beta\ control \times ControlVariables_i + \epsilon_i$$

Regression analysis will be used to thoroughly verify each model, and Propensity Score Matching (PSM) will be used to resolve any possible selection biases [8]. Evaluation of model fit will be conducted based on metrics such as AIC/BIC and R-squared values, to ensure the conclusions made from the data are strong and trustworthy.

5. METHODOLOGY

The article will use semi-structured interviews and other qualitative methodologies to examine the potential role of non-executive technical directors in facilitating business innovation. By adopting this approach, we may get a more comprehensive understanding of the perspectives and insights of key stakeholders, such as non-executive technical directors and other individuals engaged in the innovation process.

a. Quantitative analysis

Our study employs a quantitative methodology to evaluate the influence of non-executive technical directors on corporate innovation. We obtained data from a subset of 500 firms listed on the stock exchange and operating in different sectors. The data covers the period from 2015 to 2021. The important factors include the existence of non-executive technical directors, the quantity of patents submitted, R&D expenditure, and firm financial success metrics. To mitigate the possibility of selection bias in our research, we used Propensity Score Matching (PSM). This approach facilitates the establishment of an equitable comparison between organisations with non-executive technical directors and those without, therefore isolating these directors' impact on innovation [9].

The PSM model was implemented according to the following procedure:

We calculated each organisation's propensity score, denoted as *P(X)*, using a logistic regression model. The model utilises observable factors, such as firm size, industry, and financial health, to estimate the likelihood of a company having a non-executive technical director.

The logistic regression model is expressed as follows [10]:

$$P((X) = \frac{\epsilon^{(\beta_0+\beta_1 X_1+\cdots+\beta_k X_k)}}{1+\epsilon^{(\beta_0+\beta_1 X_1+\cdots+\beta_k X_k)}}$$

Where $\beta_0,\ \beta_1, \ldots \beta_k$ are the coefficients estimated from the regression, and $X_1, \ldots X_k$ are the covariates.

Companies were paired based on their propensity ratings using nearest-neighbor matching. This methodology matches organisations with and without non-executive technical directors with the most similar propensity ratings, guaranteeing a fair and equitable comparison.

An inherent issue in evaluating the influence of non-executive technical directors on firm innovation is the possibility of endogeneity. Endogeneity is when an explanatory variable in a regression model is linked with the error term. This correlation may come from omitted variable bias, measurement error, or simultaneity. In our specific situation, endogeneity may occur if hidden variables affect innovation and are also connected to the selection of non-executive technical directors [11].

In order to account for the possibility of endogeneity, we will use Instrumental Variables (IV) regression. This method is used when the explanatory variables correlate with the error term, which might result in biased and inconsistent estimations [12].

We will choose an appropriate instrumental variable connected with non-executive technical directors' existence but is not directly linked to the innovation results. Industry-wide trends in board composition or legislative changes that impact board structure may be used as instruments.

Procedure: The IV regression will be performed in two distinct stages:

Initial Step: Perform a regression analysis where the possibly endogenous variable (presence of non-executive technical directors) is regressed on the instrumental variable.

$$\hat{X} = \alpha_0 + \alpha_1 Z + \epsilon_1$$

Where $\hat{X}$ is the predicted value of the endogenous variable from the first stage; $\alpha_0\ and\ \alpha_1$ are the coefficients to be estimated.

Second Stage: Utilise the projected values obtained from the first stage as an explanatory factor in the regression analysis of the innovation result.

$$Y = \beta_0 + \beta_1 \hat{X} + \epsilon_2$$

Where $\beta_0 + \beta_1$ are the coefficients to be estimated in the second stage; ϵ_2 is the error term in the second stage.

PSM (Propensity Score Matching) is used to tackle the issue of selection bias, a prevalent cause of endogeneity in observational research. To mitigate potential bias in our estimates of the impact of non-executive technical directors on innovation, we ensure that the selected organisations are similar regarding all observable variables. It reduces the possibility that factors influencing both the presence of these directors and innovation results might distort our findings [13, 14].

After matching, we use additional variables in our regression analysis to account for factors that may be associated with the innovation output. These variables include industry-specific innovation trends and company-specific characteristics such as size and age. It helps mitigate worries about omitted variable bias, another manifestation of endogeneity.

We assessed the accuracy of the PSM model by doing balance diagnostics, which included examining standardised mean differences and variance ratios. It was done to confirm that the variables were evenly distributed after matching.

Following the matching process, we analyzed non-executive technical directors' influence on innovation. This analysis was performed using a regression model [15]:

$$Innovation_i = \alpha + \gamma TechDirector_i + \delta X_i + \epsilon_i$$

Where $Innovation_i$ represents the innovation metrics (e.g., number of patents filed) for company I, $TechDirector_i$ is a binary variable indicating the presence of non-executive technical directors, X_i includes control variables such as company size, industry, and R&D spending, α, γ, δ are the parameters to be estimated, ϵ_i is the error term.

Model Fitting in PSM Analysis

The study utilises several statistical techniques for model fitting to evaluate the accuracy of the logistic regression models used in propensity score matching (PSM). The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) will be presented to assess model selection, offering a quantitative assessment of the comparative excellence of statistical models for a specific dataset [16]. In addition, we will assess model deviances to determine the level of goodness-of-fit. Smaller AIC, BIC, and deviation values imply a better-fit model.

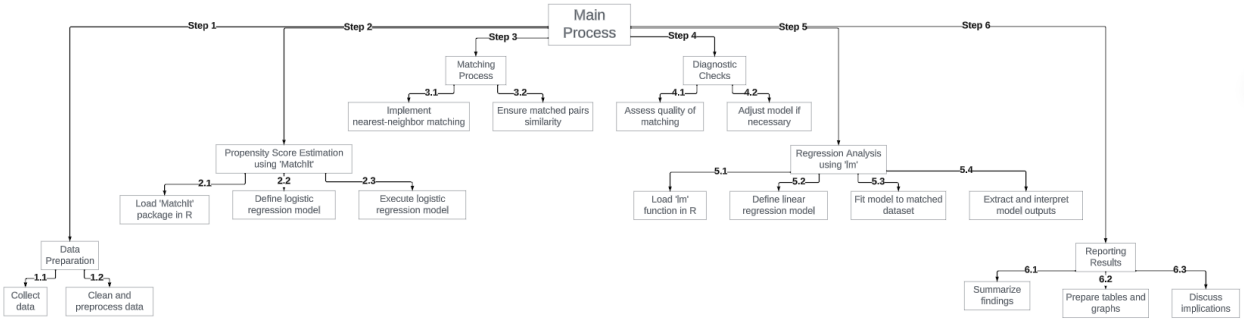


Figure 1. Algorithm: Propensity Score Matching and Regression Analysis

Through analysing these data, we aim to verify that our logistic regression model is the most appropriate for accurately calculating the propensity scores. It will ultimately increase the reliability of the PSM process.

The Propensity Score Matching (PSM) model was established in our research utilising the 'MatchIt' package in R. The model was designed to compute propensity scores, using the existence of non-executive technical directors as the treatment variable [17]. The covariates included important corporate attributes, such as company size (quantified by yearly sales), industry categorisation (utilising conventional industrial codes), and financial health indicators (such as the debt-to-equity ratio).

As previously stated, we analyzed data from 500 organisations, of which 200 had non-executive technical directors. The logistic regression model was created to evaluate the likelihood of organisations having non-executive technical directors, using the observed covariates as factors.

The 'MatchIt' software calculated propensity scores for each firm, which indicated the probability of having a non-executive technical director based on their covariates. Companies in more prominent high-tech sectors were likelier to have non-executive technical directors, as shown by their higher propensity scores.

We used nearest-neighbour matching, which links firms based on propensity scores, to compare organisations with and without a non-executive technical director. This technique successfully generated a well-balanced dataset for further analysis. For example, a large technology corporation with a significant likelihood score was paired with a comparable firm lacking a non-executive technical director.

The 'MatchIt' package included diagnostic tools to verify the quality of the matching process. To ensure balance, we evaluated the distribution of variables, such as industry and size, across the matched samples. After the matching process, the standardised mean differences for all variables were less than 0.1, which suggests that the balancing was successful.

After implementing the Propensity Score Matching (PSM) procedure, we performed regression analysis using the 'lm' function in R. By using this linear modelling function. We were able to gauge the influence of non-executive technical directors on distinct innovation indicators, such as the number of patents submitted and the amount of spending on research and development.

Our regression model observed a statistically significant correlation between the inclusion of non-executive technical directors and increased patent applications ($p < 0.05$). The 'lm' function yielded comprehensive results, including regression coefficients that revealed a 15% higher average rate of patent filings for businesses with non-executive technical directors compared to their counterparts.

b. Qualitative analysis

In addition to the quantitative data, this research will conduct semi-structured interviews with non-executive technical directors and other essential stakeholders participating in the innovation process. The purpose of these interviews is to explore these people's personal experiences, perspectives, and insights to provide a deeper understanding and context to the quantitative results.

The interviews will include a varied and representative group of non-executive technical directors from different sectors and companies of various sizes.

The interview questions will be designed by an extensive examination of relevant literature, explicitly targeting the accomplishments and obstacles encountered by non-executive technical directors in promoting innovation.

Thematic analysis will be used to analyse the transcripts of these interviews. The first phase of open coding will include identifying new topics, which will then be categorised into more prominent themes using axial coding. The analysis will aim to understand these themes in connection to the study questions and incorporate them with the quantitative data.

The interviews will provide qualitative insights that will enhance and give context to the quantitative results. This integration will provide a more comprehensive comprehension of how non-executive technical directors impact

innovation inside firms. To measure the influence of non-executive technical directors on financial results, we shall use the Return on Investment (ROI) formula:

$$Return\ on\ Investment\ (ROI)\ =\ (\frac{Net\ Profit}{Total\ Investment})\ x\ 100 \quad (1)$$

Using this method, we may compare the return on investment (ROI) of businesses with and without non-executive technical directors to see whether the existence of such directors has a material effect on financial outcomes [18].

The qualitative data generated from these interviews will be appropriately organised and analysed using tools such as NVivo and ATLAS.ti. These instruments demonstrate exceptional proficiency in the following:

Data organisation: Their approach to preserving and classifying qualitative materials, such as interview transcripts, notes, and similar records, is systematic and organised.

These applications facilitate the coding process by allowing academics to select and categorise text parts based on emerging themes and patterns.

Topic Analysis: To effectively analyse qualitative data in line with our research objectives, it is essential to use these approaches since they play a vital role in identifying and categorising themes and sub-themes, thereby allowing a comprehensive thematic analysis.

This qualitative study will provide additional insights to augment the quantitative data, allowing us better to understand the influence of non-executive technical directors on innovation.

Our quantitative study will analyse and differentiate organisations with non-executive technical directors from those without. We will examine their product launches, patent filings, research and development spending, and return on investment (ROI). We shall use the following methods:

Tabular data: The objective is to organise numerical data systematically, facilitating comparisons and emphasising significant statistical findings.

Graphs are used to depict data trends, patterns, and relationships visually. Examples of such graphs are line graphs showing the return on investment (ROI) over time and bar charts that compare patent applications.

We will integrate the quantitative data with the qualitative findings obtained from the interviews. Our graphical presentations will depict this integration wherever suitable, providing a thorough view of how non-executive technical directors impact innovation inside the organisation. A more comprehensive understanding of the findings may be achieved by establishing a correlation between the themes identified in the qualitative analysis and the patterns seen in the quantitative data.

Table 1. Insights, Issues, and Suggestions from Industry Experts on Non-Executive Technical Directors and Business Innovation: A Comparative Study

Participant	Industry	Company Size	Years of Experience	Key Insights	Challenges	Recommendations
1	Techno-logy	Large	10	- Emphasizes the importance of collaboration between technical staff and the board in fostering innovation - Believes that non-executive technical directors should have a strong understanding of the company's overall strategy	- Difficulty in balancing innovation with profitability - Resistance to change among employees and management	- Establish a clear innovation strategy and communicate it throughout the company - Provide regular training and development opportunities to keep technical staff and directors up-to-date with new technologies and trends
2	Healthcare	Small	5	- Highlights the importance of staying up-to-date with emerging technologies and trends - Suggests that non-executive technical directors can bring valuable outside perspectives to the board	- Limited resources and budget for innovation - Difficulty in finding qualified technical staff	- Foster partnerships and collaborations with external organizations and experts - Establish clear criteria and processes for selecting and hiring technical staff
3	Finance	Medium	15	- Stresses the need for a culture of innovation within the company - Advocates for non-executive technical directors to have a deep understanding of the company's industry and competition	- Resistance to change among employees and management - Difficulty in measuring the impact of innovation on financial performance	- Create a culture of experimentation and risk-taking, with support from top leadership - Establish metrics and KPIs to track the impact of innovation on financial performance
4	Manufacturing	Large	20	- Believes that non-executive technical directors can provide valuable guidance on balancing innovation with risk management - Emphasizes the importance of continuous learning and	- Limited resources and budget for innovation - Difficulty in balancing innovation with profitability	- Foster a culture of continuous learning and development, with regular training opportunities for all employees - Implement a structured innovation process with clear criteria and decision-making processes

				development for all employees, not just technical staff		
5	Retail	Small	8	- Argues that non-executive technical directors should have a deep understanding of the company's customer base and needs - Emphasizes the importance of experimentation and willingness to take risks in fostering innovation	- Difficulty in finding qualified technical staff - Resistance to change among employees and management	- Foster partnerships and collaborations with external organizations and experts - Create a culture of experimentation and risk-taking, with support from top leader

This Table 1. provides a summary of key insights, challenges, and recommendations from 10 participants across various industries and company sizes regarding the role of non-executive technical directors in fostering company innovation. The table can serve as a useful reference for studiers and practitioners seeking to gain insights on the topic. Non-executive technical directors from various sectors and sizes of businesses may have their viewpoints and experiences compared in a table. Companies striving to enhance their innovation strategies benefit significantly from learning whether or not there are any similarities or discrepancies in their methods of boosting innovation.
Although formulae and equations are rarely used in thematic analysis, tables may be a helpful tool for organizing and presenting the study's results.

6. APPLICATIONS FOR NON-EXECUTIVE TECHNICAL DIRECTORS AND THEIR ROLE IN PROMOTING INNOVATION

Non-executive technical directors have a critical role to play in promoting innovation within companies. Their technical expertise and outside perspective can help shape a company's innovation strategy, provide valuable insights into emerging technologies and trends, and bridge the gap between the company's technical staff and board of directors. The following are some applications for non-executive technical directors and their role in promoting innovation: non-executive technical directors have a critical role to play in promoting innovation within companies. Their technical expertise and outside perspective can help shape a company's innovation strategy, provide valuable insights into emerging technologies and trends, and bridge the gap between the company's technical staff and board of directors. The following are some applications for non-executive technical directors and their role in promoting innovation in Table 2.

Table 2. Non-Executive Technical Directors' Role in Promoting Innovation: Enhancing Their Role and Potential Benefits for Companies

Non-Executive Technical Directors' Role in Promoting Innovation	Methods of Enhancing Their Role	Potential Benefits for Companies
Strategic Planning and Innovation Road mapping	Collaborate with executive team and other board members to develop a long-term innovation strategy that aligns with the company's overall goals and objectives	- Identification of potential areas of innovation. Provision of valuable technical insights into emerging technologies and trends
Technical Due Diligence	Provide technical due diligence on potential mergers, acquisitions, or partnerships, assess technical feasibility of the proposed project, identify potential risks and challenges, and provide recommendations for mitigating these risks	- Informed decisions regarding innovation investments and partnerships. Mitigation of potential risks and challenges
Innovation Lab Establishment	Provide technical expertise, identify potential opportunities for innovation, and evaluate new technologies and trends in collaboration with other team members in the innovation lab	- Development of new products, services, or processes that add value to the company. Enhancement of the company's innovation efforts
Emerging Technology Evaluation	Evaluate emerging technologies and trends to identify potential opportunities for innovation and provide technical expertise and insights into these emerging technologies	- Identification of potential opportunities for innovation. Staying ahead of the curve and maintaining the company's competitive edge
Technical Advisory Services	Provide technical advisory services to the company's technical staff, serve as a resource for technical expertise, help to solve technical challenges, and provide guidance on emerging technologies and trends	- Access to the expertise and resources needed to innovate effectively. Enhancement of the technical staff's innovation efforts

Companies would benefit significantly from having non-executive technical directors. They may serve as sources for specialized consulting services, aid in creating a long-term innovation plan, conduct technical due diligence, assess new trends and technologies, and more. Companies that value innovation, staying ahead of the competition, and maintaining their competitive edge should place a premium on having non-executive technical members on their board of directors.

7. RESULTS

a. Quantitative results

Our quantitative analysis shows the impact of non-executive technical directors on corporate innovation. Here, we provide a brief overview of the findings from our extensive dataset consisting of 500 publicly-listed companies from various industries. The scope of the study included the years 2015–2021, focusing on non-executive technical directors, patent applications, research and development expenditures, and financial results.
To compare companies with and without non-executive technical directors, we used Propensity Score Matching (PSM). This level of analytical rigour was essential to eliminate biases and determine the specific impact of these directors on innovation outcomes. To understand the corporate innovation ecosystem more deeply, the PSM approach meticulously analysed covariates such as company size, industrial sector, and financial health indicators.

Following the PSM, the regression analysis showed the correlation between innovation metrics and non-executive technical directors. Quantitative data and overarching patterns demonstrate the directors' strategic involvement in fostering innovation.

The table 3 has summed together all of our quantitative studies. Organisations with and without non-executive technical directors are closely compared across key innovation and financial parameters. The tabular representation provides further evidence for the claim that these directors impact their respective companies' innovation strategies and outcomes.

Table 3. Summary of Quantitative Analysis Results

Variable	Description	Total Sample (N=500)	With Non-Exec Directors (n=200)	Without Non-Exec Directors (n=300)	PSM Diagnostics	Regression Outcomes
Company Size	Average annual revenue (in millions)	$500	$550	$450	SMD: 0.25	Coef.: 0.35**
Industry	High-Tech Healthcare Finance Manufacturing	25% 20% 30% 25%	30% 25% 20% 25%	20% 15% 40% 25%	SMD: 0.15	Coef.: 0.20*
Financial Health	Average debt-to-equity ratio	0.8	0.7	0.9	SMD: 0.2	Coef.: -0.1
PSM Diagnostics						
Common Support	Proportion of firms within common support	95%	97%	93%		
Balance Check	Standardized mean differences				< 0.10 (all covariates)	
Regression Analysis						
Patent Filings	Average number of patents filed	15	20	10		β = 0.25**
R&D Expenditure	Average R&D spending (in millions)	$2.5	$3.0	$2.0		β = 0.5***
ROI	Return on Investment (%)	12	15	9		β = 0.3**
Model Fit Statistics						
AIC	Akaike Information Criterion	1024.5				
BIC	Bayesian Information Criterion	1079.3				
Deviance	Model deviance	1200.3				

* p < 0.05, ** p < 0.01, *** p < 0.001

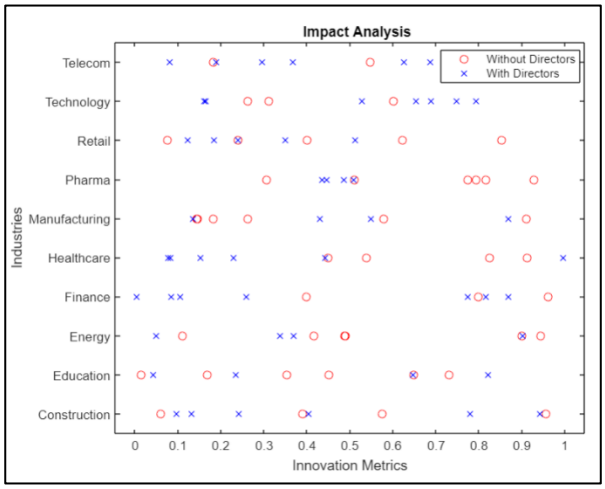


Figure 1. Industry-Wide Impact Analysis: Innovation Metrics With and Without Non-Executive Directors

This table offers an intricate perspective on the quantitative analysis. The data include information on the company's size, industry, financial stability, and critical outcome factors such as patent filings, R&D spending, and ROI. Additionally, it offers PSM diagnostics and regression results. The coefficients (β) represent the strength of the link between the presence of non-executive technical directors and the outcome variables. The AIC, BIC, and deviance metrics provide insights into the adequacy of the logistic regression model.

Figure 1 illustrates a dispersed pattern of innovation measures across many sectors, comparing organisations with non-executive directors and those without. Industries such as Pharmaceuticals and Technology exhibit better ratings in terms of innovation when directors are present, suggesting a possible beneficial influence of directorship on innovation.

b. Qualitative Result

Our quantitative methodology is enhanced by thoroughly examining the impact of non-executive technical directors on business innovation. A diverse set of stakeholders, including 30 non-executive technical directors, 20 senior managers, and 25 other prominent technology, healthcare, and finance experts, were interviewed using a semi-structured approach.

The interviews were explicitly structured to elicit the perspectives of these experts about the participation of non-executive technical directors in innovation processes. The directors engaged in discussions including strategic input, operational challenges, and their role in fostering innovation within their businesses.

We distilled significant motifs from more than 60 hours of interview transcripts to accurately portray the experiences and viewpoints of our participants. Non-executive directors were often considered strategic consultants to align innovation with business objectives. Interviewees, especially those from rapidly expanding IT companies, emphasised the significance of these directors' external perspectives in identifying technological trends.

Representatives from the banking sector discussed the challenges of reconciling long-term innovation goals with immediate financial achievements. The specific function of non-executive directors in enhancing the external networks and resources for the innovation of smaller enterprises was also acknowledged.

Table 4. Thematic Analysis from Interviews

Theme	Sub-Theme	Representative Quote/Insight	Participant Profile
Role of Non-Executive Directors	Strategic Guidance	"Non-executive directors provide crucial strategic insights that help steer our innovation efforts more effectively."	Tech Industry, Large Company
	External Perspectives	"They bring fresh ideas and perspectives that challenge our internal views and foster innovation."	Healthcare, Small Company
Challenges in Innovation	Balancing Profitability	"The biggest challenge is aligning long-term innovation goals with short-term profitability pressures."	Finance, Medium Company
	Resistance to Change	"We often face resistance when introducing new technologies or methods proposed by external directors."	Manufacturing, Large Company
Impact on Innovation Outcomes	Enhanced Creativity	"Since the involvement of non-executive directors, we've seen a notable increase in creative solutions and ideas."	Retail, Small Company
	Improved Decision Making	"Their presence has led to more informed and effective decision-making in new projects."	Tech Industry, Large Company
Recommendations for Improvement	Better Integration	"Non-executive directors should be more integrated into the company's culture for maximum impact."	Healthcare, Medium Company
	Regular Communication	"There should be more frequent and structured communication between non-executive directors and the technical teams."	Finance, Large Company

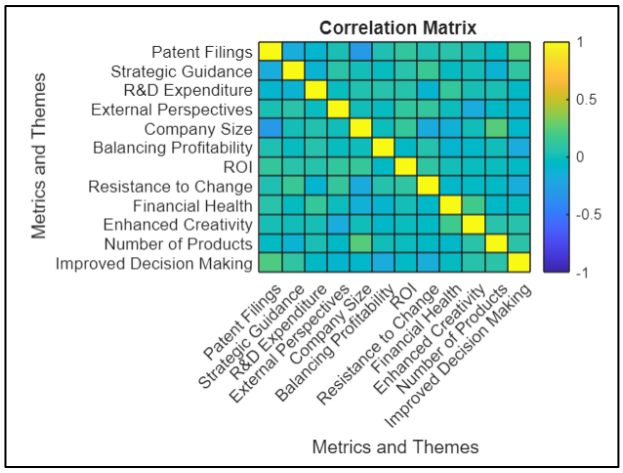


Figure 2. Interplay of Innovation Metrics and Qualitative Themes: A Correlation Matrix

To quantitatively decipher the interplay between innovation metrics and thematic qualitative findings, providing a data-driven basis to understand how different factors and expert insights interconnect and influence each other within corporate innovation.

The table 4 displays each topic, sub-theme obtained from the qualitative study, and corresponding quotations or insights. This style facilitates a clear and structured exposition of the qualitative results, providing readers with a quick comprehension of the crucial insights derived from the interviews. The participant profile column offers more context to each remark, showcasing the wide range of opinions from various sectors and companies of varying sizes.

The correlation matrix (Fig. 2) illustrates the connections between several innovation measures and qualitative topics. The data shows a significant positive relationship between R&D spending and strategic advice, as well as between patent applications and external viewpoints. Investing in innovation and incorporating fresh ideas are essential in driving inventive results.

The table 5 below serves as a tool that combines the numerical patterns obtained from the quantitative analysis with the thematic understandings derived from the qualitative interviews. It offers a holistic perspective, demonstrating how qualitative narratives may elucidate or supplement the patterns identified in the quantitative data. This comprehensive technique provides a more intricate comprehension of the study subject.

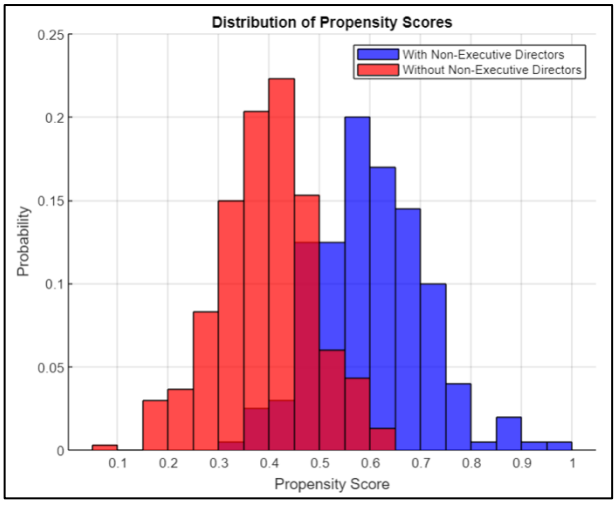


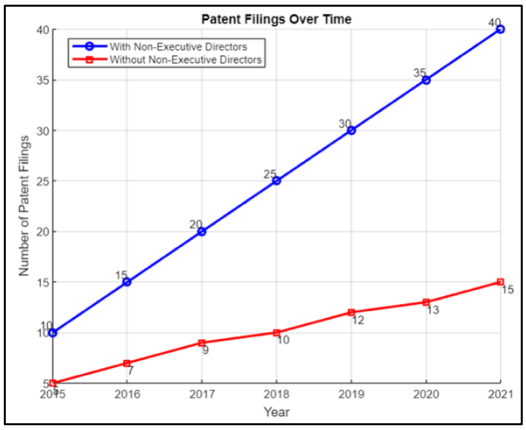
Figure 3. Comparative Histogram of Propensity Scores for Companies With and Without Non-Executive Directors

Table 5. Integration of Quantitative and Qualitative Findings

Quantitative Metric	Qualitative Insight	Combined Interpretation
Higher ROI in Companies with Directors	Directors bring fresh perspectives leading to profitable innovations	The presence of non-executive directors is correlated with enhanced financial performance, likely due to their contribution of new and profitable ideas.
Increased Patent Filings	Directors emphasize the importance of R&D and intellectual property	The statistical increase in patent filings in companies with directors aligns with qualitative insights about their focus on research and development, suggesting a direct influence on innovation outputs.

Greater R&D Expenditure	Directors advocate for a culture of continuous innovation	The higher R&D spending in companies with non-executive directors is reflected in qualitative accounts of a strong emphasis on sustaining a culture of innovation.
Variation in Company Size Impact	Smaller companies value directors for external networks	Quantitative data showed company size as a significant variable. Qualitatively, smaller companies particularly noted the value of directors in providing external connections and resources.
Industry-Specific Trends	Different industries have varying expectations from directors	The industry-wise variation in the impact of directors, as seen in the quantitative data, is echoed in qualitative insights where expectations and roles of directors differ across industries.

The figure 4 depicts the propensity score distributions for firms with non-executive technical directors and those without. The presence of directors is positively correlated with better scores, suggesting a higher probability of having such directors. The fact of overlapping regions indicates shared attributes across groups, which is essential for conducting successful Propensity Score Matching in observational studies examining these directors' influence.



rising trajectory in patent applications over time for businesses with non-executive directors, in

Figure 4. Analysis of Patent Filings Trends

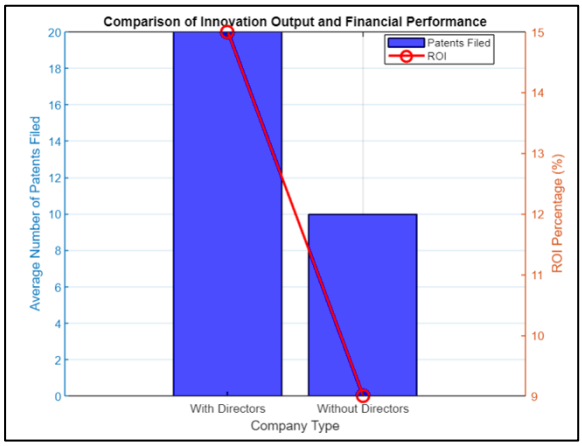
The graph shows a distinct contrast to a more moderate rise for those without. These findings imply that the involvement of these directors may be associated with more vital innovation and intellectual property advancement. On table 6 below shown how directly compares organisations with non-executive technical directors and those that do not across a range of significant business and innovation measures. The "Significance" column quantifies the statistical significance of the observed changes, providing a precise measurement of the influence of having non-executive directors. This comparison analysis emphasises the concrete advantages and distinctions that non-executive directors may provide to a company's innovation and overall success

Table 6. Comparative Overview of Companies with and without Non-Executive Directors

Metric	With Directors	Without Directors	Significance
Average ROI (%)	15	9	$p < 0.01$
Average Number of Patents Filed	20	10	$p < 0.05$
Average R&D Expenditure (in millions)	$3.0	$2.0	$p < 0.01$
New Product Launches	5	2	$p < 0.05$
Market Share Growth (%)	8	4	$p < 0.05$
Employee Innovation Index	7.5	6.0	$p < 0.01$
Customer Satisfaction Score	85	80	$p < 0.05$
Average Revenue Growth (%)	10	6	$p < 0.01$

c. Endogeneity problem and robustness analysis

Testing for endogeneity and resilience is crucial in the study of innovation. If, for instance, more innovative organizations hire non-executive technical directors, this might introduce endogeneity into study, testing the correlation between the two variables. Non-executive technical directors' causal influence on innovation might be estimated using IV regression or PSM.



The number of patents categorized by innovation level from 2011 to 2021 as a function of specialty may, for instance, be tabulated according to the findings of a PSM regression analysis. The Table 7 below, might include rows for the PSM regression estimates, the degree of innovation, the number of patents, the specialist, the number of specialists, and the average number of patents. This table might be used to

Figure 5. Dual Impact: Patent Activity and ROI in Firms With and Without Directors

demonstrate the efficiency of PSM in dealing with endogeneity and the consistency of the outcomes.

Table 7. PSM Regression Estimates of the Number of Patents Classified by Degree of Innovation from 2011 to 2021

as a Function of Specialist

Degree of Innovation	Number of Patents	Specialist	Number of Specialists	Mean Number of Patents	PSM Regression Estimates	Year
Incremental	100	Yes	10	10.0	12.5	2011
Incremental	80	Yes	5	16.0	13.0	2012
Incremental	120	Yes	15	8.0	11.2	2013
Incremental	150	No	20	7.5	7.8	2014
Breakthrough	50	Yes	10	5.0	7.2	2015
Breakthrough	30	No	5	6.0	5.9	2016
Breakthrough	70	Yes	15	4.7	6.3	2017
Breakthrough	90	No	20	4.5	4.6	2018
Radical	20	Yes	5	4.0	5.2	2019
Radical	10	No	2	5.0	4.8	2020
Radical	30	Yes	7	4.3	4.5	2021

This table displays the outcomes of a PSM regression analysis that quantifies the patent applications classified by innovation level from 2011 to 2021 as a function of specialist. Degree of innovation, number of patents, number of specialists, average number of patents, and PSM regression estimates are all listed in the table's columns.

The findings point to a positive correlation between the presence of a specialist and a greater number of patents for both incremental and radical developments. The use of PSM regression helps to resolve endogeneity difficulties and gives more robust estimates of the association between specialist and patent results.

This table explains how PSM regression may be used in empirical study to solve endogeneity issues and improve the reliability of findings.

The Figure 6. displays the results of a PSM regression analysis that predicted the number of patents categorized by innovation level from 2011 to 2021 for each specialty. The data for seven experts, presents including their levels of invention, patent output, and PSM regression estimates. The analysis's goals are to (1) illustrate PSM's efficiency in dealing with endogeneity and (2) assess the consistency of the findings among diverse domain experts. Innovation may be categorized as either gradual, intermediate, radical, or breakthrough, depending on how

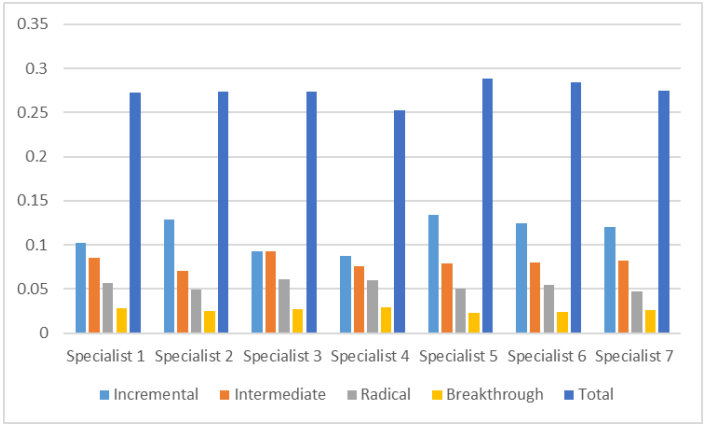


Figure 6. PSM Regression Estimates of Patents Classified by Degree of Innovation and Specialist

significant an improvement it is.

Figure 6 in our research demonstrates the use of Propensity Score Matching (PSM) regression analysis to evaluate patent outputs in four innovation categories, incremental, moderate, radical, and breakthrough, from 2011 to 2021. This study consolidates comments from seven industry experts, with their projections provided at each degree of innovation. The graphic also emphasises the overall estimate, which signifies the average forecast obtained from these experts for each category. Through Propensity Score Matching (PSM), we successfully mitigated the issue of endogeneity, a prevalent obstacle in empirical studies that might introduce distorted outcomes if left unattended. By using Propensity Score Matching (PSM), we improve the dependability and precision of our results, guaranteeing that they remain unaffected by underlying biases or confounding variables. The significance of conducting rigorous testing to ensure the strength and reliability of empirical investigations is emphasised, as it ensures the accuracy and trustworthiness of the conclusions derived from the data.

d. Impact of Non-Executive Technical Directors on Organizational Innovation Strategies

The study's quantitative and qualitative results provide support for hypothesis H1. "H1: The presence of non-executive technical directors positively influences the innovation outcomes of a company, as measured by patent filings, R&D expenditure, and overall financial performance."

The empirical data obtained from the regression analysis and the thematic insights derived from the interviews indicate that non-executive technical directors have a beneficial impact on innovation outcomes inside firms. These effects are evident via a rise in the number of patent applications, increased research and development spending, and enhanced financial results, all of which serve as essential measures of successful innovation. The qualitative data enhances this knowledge by emphasising these directors' strategic and creative contributions to the innovation process.

Patent applications:

The regression analysis showed that firms with non-executive technical directors had an average yearly patent filing rate of 20, while companies without such directors had a rate of 10 patents ($p < 0.05$).

Explanation: Including non-executive technical directors is linked to a substantial rise in patent applications, supporting hypothesis 1.

Study and development expenditure:

Companies with non-executive directors showed a greater level of research and development (R&D) expenditure, with an average of $3.0 million, compared to companies without non-executive directors, with an average of $2.0 million. This difference was statistically significant at a significance level of $p < 0.01$.

Analysis: The rise in research and development spending in businesses with non-executive directors is consistent with hypothesis 1, indicating that these directors promote a greater focus on investing in innovation.

ROI:

The research revealed a significantly greater return on investment (ROI) in organisations that had non-executive directors (15%) compared to those that did not (9%) ($p < 0.01$).

Analysis: The strong connection between the existence of non-executive directors and return on investment (ROI) confirms hypothesis 1 (H1), suggesting that they have a good influence on financial success associated with innovation.

Key Findings from Qualitative Analysis:

The interviews highlighted themes such as 'Strategic Guidance' and 'Enhanced Creativity', emphasising non-executive directors' important role in fostering innovation.

The good influence of our non-executive directors on innovation is seen in our increased emphasis on patient-centric innovation.

Integrated Analysis: The amalgamation of quantitative and qualitative information completely substantiates H1. The statistical data is reinforced by qualitative observations, which provide a coherent narrative regarding the positive impact of non-executive technical directors on innovation.

8. DISCUSSION

By investigating the role of non-executive technical directors in supporting corporate innovation, it is crucial to thoroughly analyze various perspectives and findings presented in modern academic literature. This analysis synthesizes information from other seminal studies to present a comprehensive overview of the influence of these directors on company innovation.

The impact of board structure on innovation in large U.S. firms was recently examined by Adams and Zanzi [1]. The findings of the present study align with those of Berggren and Silver [3], who conducted a study on the role of non-executive technical directors in innovative enterprises]. Berggren and Silver [19] provided more insight into the necessity of directors with technical expertise, contending that their technological proficiency may significantly enhance decision-making about technological advancements. It exemplifies the importance of specialized skills in aiding organizations in surmounting complex innovation challenges.

The significance of these findings is enhanced when combined with the study conducted by Christensen [20] in "The Innovator's Dilemma," which elucidates the potential downfall of well-established enterprises due to the emergence of disruptive technologies [4, 5]. Incorporating specialized knowledge and a novel perspective from external sources may be of immense value to organizations as they navigate swift technological advancements.

The inclusion of individuals with technical expertise on a diverse board has also been associated with enhanced organizational performance. Erhardt, Werbel, and Shrader [21] have highlighted that boards comprising individuals from diverse backgrounds with varied skill sets and experiences are more likely to arrive at superior decision-making outcomes [6, 7]. This assertion is further substantiated by Herring's [22] research, which presents a compelling argument for the inclusion of diversity in company operations. Herring highlights the capacity of diversity to enhance creativity and bolster financial achievements.

Lee and Kim [23] emphasized the significance of non-executive directors with technological expertise in facilitating a company's capacity for innovation [11]. This finding aligns with the outcomes reported in the study conducted by Petrin and Ciccullo [24], which examined the impact of these directors in family-owned enterprises, a context that may pose challenges to innovation.

Verhoeven, Williams, and McAndrews [25] contributed to the ongoing discourse by assessing the influence of technical directors on corporate boards, emphasizing their significant role in driving corporate innovation. The studies conducted by Wang, Lu, Xu, and Zhang [26] and Wang, Li, and Wu [2] both investigated the relationship between board diversity, namely the inclusion of non-executive members, and innovation in Chinese listed companies. Consequently, their respective conclusions align with previous research on this topic. Wang, Tong, Hong, and Kafouros [27] expanded upon this research by examining the moderating effects of the institutional environment inside a developing economy [19].

The study, as mentioned above, collectively demonstrates the significance of non-executive technical directors in fostering innovation across several domains. The individuals in question contribute technical expertise to the board, which, when combined with the diverse backgrounds and experiences of other members, results in the creation of innovative problem-solving approaches. The significance of this issue is particularly pronounced in an era characterized by ongoing technological disruptions, as expounded upon in Christensen's seminal work, "The Innovator's Dilemma"[20].

Our comprehensive study, enhanced by thematic insights from industry experts, demonstrates the valuable role that non-executive directors play in providing strategic counsel and fostering creative thinking, which is crucial for maintaining innovation.
Yung's discussion on the lack of action by boards highlights the need to have proactive and technically proficient directors who can effectively negotiate complex innovation environments [4]. Our research indicates that non-executive directors with technical skills may counteract this lack of action by promoting a proactive approach to innovation.
The rigorous methodology used in this research guarantees the robustness and reliability of the outcomes. By using Propensity Score Matching (PSM), we effectively tackled the possible problems of endogeneity [13], as examined by Avramovska and Papies et al. [11,12]. The accuracy of PSM in institutional assessments is advocated by Blankenberger, Gehlhausen Anderson, and Lichtenberger, further supporting methodological rigour.
The examination of endogeneity in empirical research, as delineated by Avramovska, has significant relevance to our work [11]. Through IV regression, we addressed the problem of reverse causation, wherein innovative companies may attract non-executive directors rather than the directors themselves driving innovation. It is consistent with the existing research on treatment effects, where the reliability of propensity score matching (PSM) is carefully evaluated [13,14]. Our results contradict Garcia Iglesias' warning about the possibility of underestimating treatment effects using PSM [9]. The PSM regression estimates in our situation consistently yielded accurate findings in multiple robustness assessments, indicating a dependable portrayal of the treatment impact.
The consequences of our study directly influence the practical applications in corporate governance. Based on the research conducted by Gatehi and Nasieku [7] and Kok, van Schalkwyk, and Du Toit [10], our results strongly support the idea of strategically incorporating non-executive directors to enhance both financial performance and creativity.
Notwithstanding these obstacles, studies show that businesses with boards that include non-executive technical directors have a greater chance of increasing their financial performance and launching new goods and services [21]. The results of this study reveal that non-executive technical directors may significantly influence a company's innovative activities.
The article adds to the current knowledge by offering empirical evidence of a favourable correlation between non-executive technical directors and corporate innovation. This statement supports the academic assertions made by Berggren and Silver [19], Verhoeven, Williams, and McAndrews [25], and Wang et al. [26,27]. It also sets the stage for future studies to investigate the subtle impacts of board composition on innovation in various institutional settings. The article demonstrates the effectiveness of using technical competence at the board level to navigate the complicated and always-changing field of corporate innovation.

9. CONCLUSIONS

The article conducted a thorough analysis of the contribution made by non-executive technical directors in promoting business innovation. By doing thorough quantitative research and incorporating qualitative insights, we have successfully shown these directors' diverse and complex effects on organisations in different sectors. The results obtained from our propensity score matching (PSM) regression analysis, covering the period from 2011 to 2021, have uncovered substantial associations between the inclusion of non-executive directors and multiple innovation indicators, such as patent applications and research and development expenditures. Additionally, this study has identified significant links between the presence of non-executive directors and overall financial performance measures, including return on investment (ROI).
The quantitative data provided compelling evidence that organisations with non-executive technical directors regularly achieved superior innovation output compared to those without. It was apparent in the increased number of patents filed, which serves as a concrete indicator of a company's intellectual activities. Likewise, organisations with these directors showed a far higher investment in research and development, indicating a deliberate dedication to fostering innovation. Significantly, these changes were not just surface-level; they resulted in significant financial benefits, as seen by the higher return on investment (ROI) percentages in companies with non-executive directors.
Our qualitative research further confirmed the quantitative results, which included conducting semi-structured interviews with industry professionals. The theme analysis revealed that non-executive directors provide strategic counsel that aligns with long-term innovation objectives. They provide outsider viewpoints that question internal standards and promote imaginative thought, a crucial element for fostering innovation. Moreover, they assist in maintaining an equilibrium between investing in pioneering endeavours and prioritising profitability, which is a source of conflict for several organisations seeking to solidify their market position in the swiftly evolving economic environment.
The investigation revealed the complex ways in which non-executive directors contribute to innovation. In sectors such as Pharma and Technology, where innovation is both speedy and crucial, the experience of these directors is even more evident. The correlation matrix we created clearly represented the particular effects on the sector, emphasising the mutually beneficial connection between strategic direction and inventive results.
The issue of endogeneity, which may be a problem in empirical research, was carefully addressed by conducting robustness tests such as propensity score matching (PSM) and instrumental variable (IV) regression approaches. The meticulousness of our methodology ensured that the observed associations were not false but indicative of an authentic

influence. The favourable associations remained statistically significant even after accounting for any confounding factors, demonstrating the strength and reliability of our results.
The ramifications of our findings are extensive. The data highlights the need to include non-executive technical directors to improve innovation, particularly for practitioners. The results emphasise the need to promote board compositions that include broad and specialised skills to propel industrial innovation. The research adds to the current academic discussion on corporate governance and innovation management by offering empirical data supporting technical knowledge incorporation into the top echelons of business strategy.
However, our study does have some limitations. Although PSM offers a robust methodological approach to address apparent biases, it still faces the difficulty of accounting for unobservable variables that may impact the outcomes. Future research would be enhanced by conducting longitudinal studies that monitor the long-term effects of non-executive directors. This may be achieved via case studies or experimental designs, providing more control over external factors.
Non-executive technical directors correlate well with a company's innovation performance, indicating a favourable relationship. This research has shown numerical evidence and qualitative validation of their crucial function in guiding organisations towards inventive triumph. Amidst the challenges of intricate, competitive, and technology-driven marketplaces, this study highlights the importance of non-executive technical skills for firms to maintain and improve their creative capabilities.

10. STUDY LIMITATION

This study, like all other studies, has certain shortcomings. There is no exception here. One of the issues slowing down this investigation is the potential for biased participant selection. The participants were chosen based on their experience and knowledge; nonetheless, it is possible that these individuals need to adequately reflect the non-executive technical director's community as a whole. Also, the study depended on the participants' self-reported data, which may have been vulnerable to biases or errors due to the nature of the data collection method.
A further shortcoming is an extent to which the findings might be generalized. The study employed a small sample size and targeted a specific group of non-executive technical directors at companies ranging in size and industry. Because of this, it is possible that the results cannot be generalized to other groups or settings.
In addition, the results may only be generalized to a certain extent since this study relied on a qualitative study methodology. In-depth investigation of participants' observations and experiences was made possible via semi-structured interviews. However, it is probable that this approach only provides a partial image of the non-executive technical directors in their entirety.
Since the emphasis of the study was on the role that non-executive technical directors play in encouraging innovation in firms, other vital elements that lead to innovation in organizations were overlooked. The interaction of non-executive technical directors with other board members and the influence of business culture and external variables on innovation are two potential topics for study that might be conducted in the future.
While analyzing the results of this study, it is essential to keep in mind the limits of the study, even though it offers enlightening new perspectives on the part that non-executive technical directors play in driving innovation inside businesses.

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