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# THE IMPACT OF BOARD COMPOSITION AND OWNERSHIP STRUCTURE ON INNOVATION PERFORMANCE: AN EMPIRICAL STUDY IN TAIWAN'S ELECTRONICS INDUSTRY

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**ABSTRACT**

*This research measures innovation performance from the perspective of R&D investment and patent rights and explores the impact of different board compositions and shareholding structures on corporate innovation performance. This study goes on to discuss whether the composition of the board of directors can be balanced with the shareholding structure, which will have a different impact on the company's innovation performance. The sample used in this study is a sample of Taiwan's listed OTC electronics industry for a total of five years from 2014 to 2018. The innovation value chain is used to measure the company's innovation performance, from "input (R&D expenditure) → intermediate output (patent rights) → final output (Sales) "conducted an empirical analysis. The results show that the composition of the board of directors and the shareholding structure have inconsistent effects on the company's innovation value chain, which may be beneficial to investment in research and development but not conducive to the final output (sales). External and independent directors can increase the independence of the board of directors, and can adjust the ratio of shareholding and deviation of control rights and cash flow rights of directors and supervisors, which will have a positive impact on innovation performance.*

**JEL:** C12, G30, M41

**KEYWORDS:** Board Composition, Ownership Structure, Board Independence, Innovation Performance

## INTRODUCTION

In the knowledge economy era, companies must continue learning and innovating. The purpose is to promote the company's growth, demonstrate competitiveness, and ensure a leading position. Due to the development of globalization and the popularization of the Internet, the overall environment is changing rapidly, and competition is quite fierce, especially for high-tech industries with short life cycles and rapid growth. The world economy has also evolved from a regional economy to a shared global economy that affects the whole situation. Companies must maintain their competitiveness through R&D innovation and enhance their core capabilities and value. Peter Drucker, a Master of Management, said, "Innovation or Die" companies must find opportunities to seek innovation in response to changes at any time. The importance of innovation activities is that they can enable companies to stimulate outstanding performance and are likely to be an essential element for companies to gain an advantage (Knight, 1997). In addition, the ability to innovate is also considered an asset for a company's ability to maintain a competitive advantage and carry out its overall strategy (Lawson & Samsom, 2001).

Companies' decisive assets have been replaced by intellectual capital and intangible assets (Drucker, 1993). Among intangible assets, one of the most important items for companies to create value is innovation

(Kalafut & Low, 2001). Companies are also gradually attaching the importance of accumulating intangible assets and actively investing in R&D work. Cho (1998) stated that when a company's performance is better, it should behave more funds for R&D innovation activities; therefore, performance quality can be evaluated at the level of R&D expenditure. Furthermore, according to Mairesse & Mohnen (2004) and Kim & Marschke (2004), when a company conducts R&D activities, it can assist in generating innovative results, and the results representing R&D activities are usually patent rights. R&D success is not easy, and the required R&D expenditure frequently accounts for a part of the operating income. For example, in 2018, TSMC's R&D expenditure accounted for up to 8% of net operating income. Ernst (2001) discovered that after the patent right is approved, it is deferred for 2-3 years, demonstrating that companies need to spend a lot of money and time in the innovation process, which is not easy. Requires R&D expenditure to show results to the end; it takes a lot of time and money to turn a profit for companies.

For companies, corporate governance is a crucial topic. La Porta, Lopez-de-Silanes, & Shleifer (1999) found that most companies in East Asian countries are family-controlled or government-controlled companies; they also have a pyramid structure and cross-shareholding to enhance control; however, 70% of listed OTC companies in Taiwan are family-controlled. Under the circumstance that control and management rights are not separated, controlling shareholders would have enormous incentives to deprive minority shareholders of the core agency problem. The innovation activities are highly uncertain and risky; therefore, how the composition of the board of directors and ownership structure will affect companies' innovation performance; is the research motivation of this study. Nearly half of the top 10 companies in Taiwan by market value in 2019 belong to the electronics industry, which shows that the electronics industry is of considerable importance to Taiwan's economy and industry. With the changes in the overall global economy, large factories cannot maintain the competitiveness of domestic companies solely through OEM. Only by determining the future trends will they not be eliminated in the highly competitive high-tech industry. Cainelli, Evangelista, & Savona (2004) found that innovative companies outperformed non-innovative companies in terms of productivity and economic growth; thus, innovation is an inevitable process for companies to progress. In highly uncertain and risky innovation activities, if funds are invested blindly without planning and managing their use, it will result in resource waste and failure to achieve innovation goals. The external mechanism will assist companies in carrying out their innovation activities successfully. This study uses the local listed OTC electronics industry from 2014 to 2018 as a sample. Referring to the model adopted by Yang, Cai and Wu (2008), Wang and Shen (2014). Lev (2001) stated that the innovation value chain measures innovation performance. In order to explore the impact of board composition and ownership structure on innovation performance, this study expands the research question as follows:

The impact of the board of directors' composition on innovation performance.
The impact of ownership structure on innovation performance.
The impact of board composition and ownership structure on innovation performance.

Furthermore, we contribute to this literature by exploring whether the board composition and ownership structure impacted companies' innovation performance. We also explore whether independent directors and outside directors can moderate the phenomenon of ownership concentration and positively impact companies. Our findings are inconsistent with considering the impact of the measurement variables of board composition and ownership structure on R&D investment and sales. It may be because management decisions and outside director opinions benefit the company's R&D innovation. The remainder of this paper is structured as follows: Section II discusses the relevant literature review and the development of our hypothesis. Section III describes the data sources, samples, and research methods used. Section IV shows the empirical results and analysis. The last section provides conclusions and recommendations.

## LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

OECD (1996) proposed that a knowledge economy refers to an economic formation that focuses on the possession, creation, acquisition, dissemination, and application of knowledge. Lev (2001) mentioned that intangible assets primarily drive the knowledge economy, wealth, and development. Tangible and financial assets are rapidly becoming commodities and the defining assets of businesses, and intellectual capital and intangible assets replaced tangible assets (Druker, 1993). Kalafut & Low (2001) pointed out that among intangible assets, innovation activities are among the most important items for companies to create value. Under the type of the knowledge economy, the importance of intangible assets to companies has dramatically increased. In facing fierce global competition, companies can only continue to innovate and conduct R&D to enhance their core values and competitiveness.

The company's innovation activities at different stages are not the same, and it will dominate by the product development stage. In the early stages, it will focus on developing new methods and materials to enhance competitiveness and profitability so that products will be changed more frequently. After entering the growth period stage, it will cause significant changes in the manufacturing process in response to consumer demand. After the maturity period, companies will choose product areas or innovative activities suitable to develop (Utterback, 1994). However, when companies commit to innovation activities, they must invest much money as R&D expenditures. Besides that, innovation also has a high degree of uncertainty, which causes not all companies to be willing to invest a lot of R&D expenditures on innovation activities. Cho (1998) pointed out that when the company's performance is better, it should have more funds for R&D innovation activities, so the level of R&D expenditure can assess the quality of performance.

Prior research has found that R&D expenditures positively correlate with patent rights (Artz, Norman, Hatfield & Cardinal, 2010). Strong research capabilities are also the key to enabling companies to obtain creative outputs, and companies can benefit from new products. In the prior study on the impact of indicators such as patent rights and R&D expenditure on company performance, productivity, and value, most studies argue that they have a positive effect (Griliches, 1981; Pakes, 1985; Cockburn & Griliches, 1987; Griliches, Hall & Pakes, 1998; Deng, Lev, & Narin, 1999).According to the research by Johnson and Johnston (2004), innovation performance represents products that reflect the effectiveness of new products in the market, cost, and financial performance indicators. There is inconsistency among scholars on the measurement of innovation performance. The output of new products requires integrating many resources and assets, investing funds in research and development of new technologies, obtaining patent rights, and finally integrating them to produce new products, bringing profits to the company. This is similar to the concept of innovation value chain proposed by Lev (2001), which measures innovation performance from the perspective of input (R&D expenditure) → intermediate output (patent rights) → final output (sales).

Cai, Li, and Ji (2009) proposed objective innovation performance measures, such as reports, patents, the number of papers published, and the ratio of approved projects. Subjective emphasis is placed on comparing new products with other products in terms of quality and competitors, or innovation in the industry can continue to launch new products or make it possible to obtain reports and awards. In addition, these new products can even hold a high market share to cause imitation of the industry (Olson, Walker & Ruekert, 1995). Many factors affect innovation performance, roughly divided into external environmental and internal factors, including customers, competitors, laws, management systems, etc. (Cai et al., 2009). Due to the high uncertainty of innovation and insufficient public information, it is easy to cause information asymmetry between the company's internal and external information, which means the importance of highlighting the internal governance mechanism. Different internal governance mechanisms have other impacts on the company's innovation performance. The following sections describe the impacts of internal governance mechanisms on innovation performance. Jensen & Meckling (1976) proposed that the traditional agency problem theory refers to a situation where control and ownership are separated; it creates a conflict of interest between the controller and the company's owner due to separating the manager and

financial provider. La Porta et al. (1999) found that companies in most East Asian countries, including Taiwan, are mostly family-controlled. Under the condition that control and management rights are not separated, it is easy to generate core agency problems. There are great incentives for controlling shareholders to deprive minority shareholders of their rights and interests.

However, many prior studies have found that agency problems bring uncertainty to the value of R&D investment (Hall & Lerner, 2010; O'Connor, Rafferty & Sheikh, 2013; Tsao, Lin & Chen, 2015). Chu, Yang, and Yang (2016) mentioned that the agency problem reduces R&D efficiency and the value of R&D investment. When there is information asymmetry between managers and financial providers, managers will tend to engage in R&D activities that serve their interests but are inefficient. Not all company's innovation performance and innovation value effects are the same and may be affected by agency problems. Unlike agency theory, Donaldson & Davis (1991) proposed the stewardship theory, in which the interests of managers and financial providers are consistent, and they work hard because of their dignity, beliefs, and the pursuit of inner satisfaction. In facing R&D investment with high uncertainty, managers will avoid the risk of unemployment, but they will even be willing to sacrifice personal interests to achieve company goals (Boyd, 1995; Donaldson & Davis, 1994). Therefore, if the stewardship theory measures the impact on innovation performance, it may positively impact innovation performance under the condition that the interests of the principal-agent are consistent.

To reduce the impact of agency problems, companies have gradually developed corporate governance mechanisms. The World Bank (1999) discusses the corporate governance structure, divided into internal and external mechanisms, from the two perspectives of corporate and public policy. The core of the internal governance mechanism lies in the board of directors, which is responsible for supervising the management and decision-making of the company. External mechanisms include the establishment of legal norms and organizations to strengthen the functions of internal mechanisms. A mature external mechanism can effectively reduce agency problems between shareholders and management. The ownership structure is closely related to corporate governance. When the company's equity is highly concentrated, the controlling shareholders may directly control the management level. Currently, the focus of corporate governance is to avoid the occurrence of core agency problems. If the company's shareholding is dispersed, the management level is held by managers who are only responsible for management. Currently, the focus of corporate governance is to establish an independent board of directors to supervise the management performance. Therefore, based on different theories and viewpoints, the different board compositions and ownership structures have a different impact on the company's decision-making and performance. It is necessary to check and balance the internal and external corporate governance mechanisms to maximize the company's value and protect the stakeholders' rights and interests, such as financial providers.

The Impact of Board Composition and Ownership Structure on Innovation Performance

Xie (2009) mentioned that the function of the board of directors could provide management consultation under the resource dependence theory, assist the company in planning strategies and engaging with the outside world, reduce the uncertainty caused by the external environment, and obtain operating resources that are helpful to the company. Prior conclusions about the impact of large-size boards on companies have been inconsistent, with over-large and over-small boards. There are advantages and disadvantages for companies. Prior studies have pointed out that the over-large board of directors can easily affect communication and efficiency problems (Dechow, Sloan & Sweeney, 1996; Abbott, Parker, & Peters, 2004). Moreover, it will reduce the board of directors to a formalization (Jensen, 1993) and then lose the board's due supervisory function. Otherwise, smaller boards are less susceptible to the influence of management, and the function of supervision is easily achieved (Beasley, 1996). Yermack (1996) pointed out that small-size boards have higher real-time strategy efficiency, and the decision-making cost of the board of directors will increase as the number of people increases. Therefore, it may not be easy to implement innovative strategies with larger boards because of their inefficiency.

However, according to the resource dependence theory, the directors of a large-size board of directors will have more diverse backgrounds, skills, and opinions on business strategies, which will help to improve company performance (Bacon & Brown, 1975); it is also more effective control and monitoring of managers' decisions and behaviors (Chen, 2008). According to the stakeholder theory, Adams, Hermalin, and Weisbach (2010) argue that a large-size board can involve other stakeholders to participate in innovation. Pearce & Zahra (1992) argue that although the more large-size the board of directors is, the more difficult it is to be dominated by managers, the more the board can refute managers' proposals. However, the large-size board members have more diverse backgrounds and industry expertise, leading to higher company performance. Most companies in Taiwan are family businesses with relatively concentrated shareholdings. Inefficiency boards of directors and communication problems are unlikely to have an impact on innovation performance. Therefore, the hypothesis of this study is as follows:

*H1a:* There is a positive correlation between board size and innovation performance.

The chairman has an important influence on the board of directors. Prior studies on the chairman and general manager have different views based on agency theory and stewardship theory. First, according to agency theory, when the same people serves as chairman and general manager when faced with decision-making, it is easy to make independent and speculative decisions, thus deepening the principal-agent problem (Boyd, 1994; Daily & Dalton, 1993; Mallette & Fowler, 1992; Morck, Shleifer & Vishny, 1989). On the other hand, according to the stewardship theory, managers are willing to sacrifice personal interests to achieve the company's goals, thus increasing the incentive to invest in R&D activities. R&D activities are highly uncertain, rely on the discretion of management, and have a high degree of information asymmetry, making it difficult to reliably estimate the appropriate amount of resources and expenditures for R&D activities. For companies, the most crucial thing is to ensure that their R&D expenditures are carried out under effective monitoring and management to increase the company's advantages (Chow, Harrison, Lindquist & Wu, 1997, Cheng, Schultz, Luckett & Booth, 2003). Gul & Leung (2004) argue that serving as the chairman and general manager at the same time will have a significant impact on the board of directors, which may reduce the board's ability to supervise and manage decision-making, thus will possibly occurring a negative impact on innovation performance. Based on this view, this study proposes a hypothesis is as follows:

*H1b:* There is a negative correlation between the chairman and the general manager of innovation performance.

The board of directors' members is composed of internal and external directors. They are not only the company's decision-makers, but it is also a key internal mechanism for supervising the company and play a vital role in corporate governance. From the standpoint of supervisory role, Hossain, Cahan, and Adams (2000) argue that the value of outside directors is related to their ability to objectively judge company performance, while inside directors lack this trait. Therefore, their effectiveness in supervising the company is limited. When the board of directors makes decisions, inside directors are less able to express their positions objectively, which makes the board's supervisory function and the objectivity of performance evaluation questionable (Daily & Dalton, 1994). Bhagat & Black (1999) divided outside directors into outside non-independent directors and independent directors. Non-independent directors are employees who have served in the company, relatives of employees, or directors who have business dealings with the company or provide consulting services. Mallette & Hogler (1995) defines independent directors as directors who have no apparent relationship with the company. Independent directors should be independent of the company and have nothing to do with the company's operations, nor hold important positions or contacts, and must have a certain degree of professional background.

Many prior studies have pointed out that establishing independent directors can improve the board of directors' independence, and board independence positively impacts company performance. According to the resource dependence theory, independent directors can help companies obtain the required resources

and improve innovation performance. They are regarded as important external human resources because of their higher monitoring ability and advanced professional knowledge (Stevenson & Radin, 2009). In addition to facing complex problems, companies also need to invest many resources when carrying out innovation activities, so it is necessary to conduct a careful evaluation. The company can not only use the supervision and professional knowledge of independent directors to help carry out innovation activities but also in the implementation stage of R&D projects; Companies can use independent directors to monitor the effectiveness of resource allocation (Desai, Kroll & Wright, 2005). Efficient use of resources can enable companies to improve the efficiency and productivity of new product development. Therefore, the hypothesis establishes as follows:

*H1c:* Companies with a higher ratio of outside directors have better innovation performance.

*H1d***:** Companies with a higher ratio of independent directors have better innovation performance.

There were two different views in the literature on the shareholding ratio of directors and supervisors in the prior. According to the "Interest Convergence Hypothesis" proposed by Jensen & Meckling (1976), which argues that the interests of management and shareholders are consistent. Therefore, it argues that the proportion of shareholders within a company is positively related to company performance. On the other hand, the "Interest Conflict Hypothesis" proposed by Jensen & Ruback (1983) argues that when the management level's shareholding ratio is higher than a certain level, it has enough voting rights or influence to protect the position from being shaken, and there may be some serious problems. "Anti-takeover behavior" to consolidate one's position, which has a negative impact on company performance.

In terms of empirical study, Wang (2001) pointed out that the insider shareholding ratio has a significant positive correlation with R&D expenditure. Because the company's insiders have the information advantage, which aligns with the hypothesis of interest convergence, when the insider shareholding ratio is higher, the company tends to choose an innovation strategy. Zeng, Zeng, and Zheng (2013) found that the higher the shareholding ratio of directors and supervisors, it is beneficial for companies to accumulate innovation capabilities through R&D and create growth opportunities. Hill & Snell (1989) and Baysinger, Kosnik & Turk (1991) found a positive relationship between ownership concentration and R&D expenditure, indicating that large shareholders can effectively control managers' innovation decisions. Following the above literature, this study proposes a hypothesis is as follows:

*H2a:* The higher the shareholding ratio of directors and supervisors, the better the innovation performance.

To examine the relationship between institutional investors and operating performance, Pound (1988) pointed out three hypotheses: the efficiency supervision hypothesis, the conflict of interest hypothesis, and the strategic cooperation hypothesis. Because institutional investors have enough resources and rich information channels, the effect of investment selection and supervision is better than that of general retail investors. According to the efficiency supervision hypothesis, strong incentives and a better ability to supervise the company's various operating strategies (Almazan, Hartzell, & Starks 2005; Chen, Harford, & Li 2007; Fama & Jensen 1983). The prior literature mentioned that when there is information asymmetry between the controller and the owner, the controller will tend to engage in R&D activities with self-interest and low efficiency because institutional investors have rich information channels and the ability to collect data. Therefore, companies with institutional investors have less information asymmetry. According to Sias (2004), institutional investors do have the ability to collect information. The study shows that institutional investors' shareholding can reduce the information asymmetry between internal and external companies, and information asymmetry is common in innovation activities. Based on the efficiency supervision hypothesis, the proposed hypothesis is as follows:

*H2b:* When the company's institutional shareholding ratio is higher, the company's innovation performance

is better.

Prior research has shown that companies in most countries, including Taiwan, are characterized by shareholding and concentration in the hands of controlling shareholders and separation of control and ownership (Claessens, Djankov, & Lang, 2002; La Porta et al., 1999). Controlling shareholders increase their control over the company through cross-shareholding, pyramid structure, and participation in company management. So that the control rights and cash flow rights are separated, which in turn produces positive incentive effects and entrenchment effects. The higher the control power, the more power the controlling shareholder must decide the company's business decisions. Therefore, in terms of incentive effect, when the control power is greater, the interests of the controlling shareholder are consistent with the company's, and there are more incentives to supervise the management level. On the other hand, when the control power is greater, it is easy to generate agency problems, resulting in large shareholders encroaching on small shareholders for profit. Since innovation activities have five characteristics: long-term investment, high risk, unpredictability, labor-intensive, and specificity (Holmström, 1989), controlling shareholders tend to be less inclined to engage in innovation activities due to self-interest incentives. Jin and Chen (2006) found that "the degree of deviation of control rights and cash flow rights" is negatively correlated with the company's patent rights. Therefore, the hypothesis of this study is as follows:

*H2c:* When the degree of deviation between the company's control rights and cash flow rights is greater, the innovation performance is lower.

Since outside directors are not actually involved in the company business, their status is relatively independent. They have professional backgrounds, which can alleviate agency problems and provide the board of directors' professional advice when making decisions. Prior studies showed that outside directors are more capable of playing the role of supervisory managers (Weisbach, 1998; Rosenstein & Wyatt, 1997). In addition, the knowledge and experience of outside independent directors can positively affect company sales growth (Kor & Sundaramurthy, 2009). Therefore, outside directors may influence the company's innovation performance by supervising the management level or having a positive influence on R&D innovation, thereby improving the company's innovation performance. Therefore, based on the above, this study establishes the following hypothesis:

*H3a:* When the ratio of outside directors of the company is higher, it has a positive impact on the shareholding ratio of directors and supervisors, thereby improving innovation performance.

*H3b:* When the ratio of outside directors of the company is higher, it has a positive impact on control rights and cash flow rights, thereby improving innovation performance.

*H3c:* When the ratio of independent directors of the company is higher, it positively impacts the shareholding ratio of directors and supervisors, thereby improving innovation performance.

*H3d:* When the ratio of independent directors of the company is higher, it has a positive impact on control rights and cash flow rights, thereby improving innovation performance.

## DATA AND METHODOLOGY

### Data Sources

The information required for this study includes the innovation performance of listed electronics companies, the board size, chairman and general manager, the ratio of outside directors, the ratio of independent directors, the shareholding ratio of directors and supervisors, the institutional investor shareholding ratio, the degree of deviation between control rights and cash flow rights, and related financial variables. The

sample data takes from the Taiwan Economic Journal (TEJ) and the Taiwan Patent Search System.

The Sample Period

This study aims to observe the impact of board composition and ownership structure on innovation performance in Taiwan's listed OTC electronics industry in the past five years. The research period was five years, from 2014 to 2018.

Sample Selection Standard

High-tech industries with a short life cycle and intense competition will actively innovate to enhance the company's competitiveness. The selected companies in this study are listed electronics companies in Taiwan. Errors caused by different economic environment systems and patent production processes can avoid. The research sample must have complete net operating income, patent rights, R&D expenditure, the board size, whether the chairman is concurrently the general manager, the ratio of outside directors, the ratio of independent directors, the shareholding ratio of directors and supervisors, institutional investors shareholding ratio, the degree of deviation between control rights and cash flow rights, and other public information. If there are omissions and extreme data, the sample will delete. Table 1 shows the total number of research samples selected from 2014 to 2018 in the listed OTC electronics industry. The initial number of samples from 2014 to 2018 was 4,171. First, the total number of samples for R&D productivity is 3,730 after excluding 441 missing values. Second, the total number of samples for R&D efficiency is 3,761 after excluding 410 missing values. Third, the number of samples for paten productivity is 2,547 after excluding 1,624 missing values.

Table 1: Sample Selection Instructions

| | **R&D Productivity** | **R&D Efficiency** | **Patent Productivity** |
|---|---|---|---|
| 2014-2018 listed Otc electronics industry | 4,171 | 4,171 | 4,171 |
| Minus: missing values | 441 | 410 | 1,624 |
| Total number of research samples | 3,730 | 3,761 | 2,547 |

*This table shows sample selection instructions. Columns 2, 3, and 4 indicate the number of final samples used in this paper, respectively.*

The Definition of Variables

In the past, most of the literature used questionnaires or the number of patent rights increases to measure innovation performance. This study refers to the empirical model used by Yang et al. (2008) and Wang and Shen (2014). Also, it adopts the innovation value chain proposed by Lev (2001), from "input (R&D expenditure) → intermediate output (patent rights) → final from the perspective of output (sales)," these three indicators are used to measure innovation performance. According to Ernst (2001), the impact of patent rights on sales revenue is about two to three years behind. Therefore, the effect of time lag must consider when setting variables. Table 2 presents the definition of the variables used in this study. The variables consist of dependent variables, independent variables, and control variables.

Table 2: Definition of Variables

| Variables | Definition |
|---|---|
| Dependent variable: innovation performance | |
| R&D productivity (RD PRODUCTIVITY) | Net operating income for the current period / The sum of R&D expenditures for the current period and the past two periods |
| R&D efficiency (RD EFFICIENCY) | The sum of patent rights in the current period and the past two years / The sum of R&D expenditures in the current period and the past two periods (the natural log) |
| Patent productivity (PATENT PRODUCTIVITY) | Net operating income for the current period (the natural log) / The sum number of patent rights in the current period and the past two years |
| Independent variable | |
| Board of director's size (BOARDSIZE) | The total number of director seats on the board |
| Chairman and General Manager (DUALITY) | This variable is a dummy variable. When the chairman and the general manager are the same people, it is 1; otherwise, 0 |
| Ratio of outside directors (OUTBOD) | It is the ratio of the number of outside directors to the total number of directors, referring to the definition of Yang and Wu (2009). Outside directors = the number of seats on the board of directors - the number of director seats held by the controlling shareholder through a family or a friendly group - the number of independent directors, as an outside non-independent director |
| Ratio of independent directors (INDBOD) | It is the ratio of independent directors to all directors on the board |
| Variables | **Definition** |
| Shareholding ratio of directors and supervisors (BSHOLD) | Dividing the number of shares held by directors and supervisors by the number of outstanding shares at the end of the year |
| Institutional investor shareholding ratio (ISHOLD) | Refer to the definitions of Yang and Wu (2009), which include four categories, i.e., dealers, domestic and foreign fund-raising (investment (internal)), the country's trust funds (investment (external)), and foreign institutional investors (foreign investors) |
| Degree of deviation between control rights and cash-flow (DEV) | According to the definition of La Porta, Lopez-de-Silanes, Shleifer, & Vishny (2002), the difference between control rights and cash flow rights had calculated. Control rights refer to the shareholding ratio ultimately controlled by the controlling shareholders, while cash flow rights refer to the controlling shareholder's final earnings distribution rights |
| Control variable | |
| Company size (SIZE) | This variable is the natural log of the company's total assets |
| Company age (AGE) | This variable is the number of years the company had an establishment |
| Debt ratio (DEBT) | Total liabilities / Total assets × 100% |
| Profitability (PROFIT) | Net profit before tax for the current period / Net revenue in the current period |
| R&d intensity (R&D) | R&D expenditures in the current period / Net sales in the current period |
| Industry year (YEAR) | The innovation performance of each year may be affected by overall economic factors. The research period is five years, from 2014 to 2018. Therefore, considering the business cycle factors, four annual dummy variables are set up as control variables |

*This table shows the definitions of the variables used in this study, including dependent variables, independent variables, and control variables.*

Table 3 presents the expected direction of the variables. According to H1a, H1c, H1d, H2a, and H2b, this study expects that innovation performance is positively correlated. Meanwhile, based on H1b and H2c, this study expects that innovation performance is negatively correlated.

Table 3: The Variable's Expected Direction

| Variable | Expected Direction |
|---|---|
| Dependent variable: innovation performance | |
| R&D productivity (RD PRODUCTIVITY) | |
| R&D efficiency (RD EFFICIENCY) | |
| Patent productivity (PATENT PRODUCTIVITY) | |
| Independent variable | |
| Board of director's size (BOARDSIZE) | + |
| Chairman and General Manager (DUALITY) | - |
| Ratio of outside directors (OUTBOD) | + |
| Ratio of independent directors (INDBOD) | + |
| Shareholding ratio of directors and supervisors (BSHOLD) | + |
| Institutional investor shareholding ratio (ISHOLD) | + |
| Degree of deviation between control rights and cash-flow (DEV) | - |
| **Variable** | **Expected Direction** |
| Control variable | |
| Company size (SIZE) | + |
| Company age (AGE) | + |
| Debt ratio (DEBT) | + |
| Profitability (PROFIT) | + |
| R&d intensity (R&D) | + |

*This table shows the variable's expected direction. RD PRODUCTIVITY : Net operating income for the current period/sum of R&D expenditures for the current period and the past two periods; RD EFFICIENCY: The sum of patent rights in the current period and the past two years/the sum of R&D expenditures in the current period and the past two periods (the natural log); PATENT PRODUCTIVITY: Net operating income for the current period (the natural log)/sum of patent rights for the current period and the past two years; BOARDSIZE: the total number of director seats on the board of directors; DUALITY: This variable is a dummy variable, 1 when the chairman and general manager are the same people, otherwise 0; OUTBOD: the number of outside directors/total number of board directors; INDBOD: the seats of independent directors/total number of board directors; BSHOLD: the number of shares held by directors and supervisors/the number of outstanding shares at the end of the year; ISHOLD: including four categories, i.e., dealers, domestic and foreign fund-raising, the country's trust funds, and foreign institutional investors (foreign investors); DEV: the difference between control rights and cash flow rights; SIZE: the natural log of the company's total assets; AGE: the number of years the company had an establishment; DEBT: total liabilities/total assets; PROFIT: net profit before tax/net revenue in the current period; R&D: R&D expenditure in the current period/net sales in the current period.*

## Empirical Models

This study uses a regression model to explore the impact of corporate board composition and ownership structure on corporate innovation performance. Innovation performance is measured by patent rights, R&D expenses, and net operating income, while the regression model (1) measures the impact of board characteristics on innovation performance and verifies H1a, H1b, H1c, and H1d. In addition, the regression model (2) measures the impact of ownership structure on innovation performance and verifies H2a, H2b, and H2c.

$$RDpro_{it}(\alpha) = \alpha_0 + \alpha_1 BODSIZE_{it} + \alpha_2 DUALITY_{it} + \alpha_3 INDBOD_{it} + \alpha_4 OUTBOD_{it} + \alpha_5 SIZE_{it} + \alpha_6 AGE_{it} + \alpha_7 DEBT_{it} + \alpha_8 PROFIT_{it} + \alpha_9 R\&D_{it} + \alpha_{10} YEAR + \varepsilon_{it} \quad (1)$$

$$RDpro_{it}(\alpha) = \alpha_0 + \alpha_1 BSHOLD_{it} + \alpha_2 ISHOLD_{it} + \alpha_3 DEV_{it} + \alpha_4 SIZE_{it} + \alpha_5 AGE_{it} + \alpha_6 DEBT_{it} + \alpha_7 PROFIT_{it} + \alpha_8 R\&D_{it} + \alpha_9 YEAR + \varepsilon_{it} \quad (2)$$

This study further uses the regression model (3)(4) to measure whether board independence can moderate ownership structure and thus impact innovation performance. This study uses model (3)(4) to verify H3a, H3b, H3c, and H3d.

$$RDpro_{it}(\alpha) = \alpha_0 + \alpha_1 BODSIZE_{it} + \alpha_2 DUALITY_{it} + \alpha_3 OUTBOD_{it} + \alpha_4 BSHOLD_{it} + \alpha_5 ISHOLD_{it} + \alpha_6 DEV_{it} + \alpha_7 OUTBOD_{it} \times BSHOLD_{it} + \alpha_8 OUTBOD_{it} \times DEV_{it} + \alpha_9 SIZE_{it} + \alpha_{10} AGE_{it} + \alpha_{11} DEBT_{it} + \alpha_{12} PROFIT_{it} + \alpha_{13} R\&D_{it} + \alpha_{14} YEAR + \varepsilon_{it} \quad (3)$$

$$RDpro_{it}(\alpha) = \alpha_0 + \alpha_1 BODSIZE_{it} + \alpha_2 DUALITY_{it} + \alpha_3 INDBOD_{it} + \alpha_4 BSHOLD_{it} + \alpha_5 ISHOLD_{it} + \alpha_6 DEV_{it} + \alpha_7 INDBOD_{it} \times BSHOLD_{it} + \alpha_8 INDBOD_{it} \times DEV_{it} + \alpha_9 SIZE_{it} + \alpha_{10} AGE_{it} + \alpha_{11} DEBT_{it} + \alpha_{12} PROFIT_{it} + \alpha_{13} R\&D_{it} + \alpha_{14} YEAR + \varepsilon_{it} \quad (4)$$

Empirical Results and Analysis

In this study, the descriptive statistics of each variable are summarized and arranged in Table 4 and Table 5. According to the following three tables, it can know that the mean size of the board of directors (BOARDSIZE) is about 7, which shows that the mean number of board directors of listed OTC electronics companies in Taiwan is seven people. The chairman and general manager mean value (DUALITY) is about 0.400, which shows that nearly 40% of the chairman and general manager of Taiwan-listed electronics companies are the same people. The mean deviation of control rights and cash flow rights (DEV) is about 7%, showing that Taiwan's listed companies in the OTC electronics industry generally have deviations in control and cash flow rights. The mean R&D intensity (R&D) is about 0.07. It shows that for every 1 yuan of net sales generated by the company, it is willing to invest 0.07 yuan as an R&D expenditure.

Table 4: Descriptive Statistics - R&D Productivity

| Variable | Number of Samples | Mean | Median | Standard Deviation | Maximum | Minimum |
|---|---|---|---|---|---|---|
| **Dependent Variable** | | | | | | |
| RD PRODUCTIVITY | 3,730 | 1.308 | 1.276 | 0.173 | 4.112 | 0.879 |
| INDEPENDENT VARIABLE | | | | | | |
| BOARDSIZE | 3,730 | 7.120 | 7.000 | 1.614 | 15.000 | 2.000 |
| DUALITY | 3,730 | 0.400 | 0.000 | 0.491 | 1.000 | 0.000 |
| OUTBOD | 3,730 | 49.612 | 50.000 | 19.168 | 100.000 | 0.000 |
| INDBOD | 3,730 | 32.378 | 33.333 | 12.970 | 80.000 | 0.000 |
| BSHOLD | 3,730 | 21.100 | 17.080 | 14.665 | 96.460 | 0.050 |
| ISHOLD | 3,730 | 36.198 | 33.900 | 22.083 | 96.950 | 0.000 |
| DEV | 3,730 | 6.983 | 1.655 | 12.496 | 93.550 | 0.000 |
| **Control Variable** | | | | | | |
| SIZE | 3,730 | 15.206 | 15.015 | 1.439 | 21.949 | 10.665 |
| AGE | 3,730 | 24.950 | 24.000 | 10.059 | 65.000 | 1.000 |
| DEBT | 3,730 | 38.650 | 37.708 | 17.241 | 99.760 | 0.904 |
| PROFIT | 3,730 | 0.032 | 0.062 | 0.568 | 12.233 | -16.268 |
| R&D | 3,730 | 0.070 | 0.038 | 0.132 | 3.294 | 0.000 |

*RD PRODUCTIVITY : Net operating income for the current period/sum of R&D expenditures for the current period and the past two periods; BOARDSIZE: the total number of director seats on the board of directors; DUALITY: This variable is a dummy variable, 1 when the chairman and general manager are the same people, otherwise 0; OUTBOD: the number of outside directors/total number of board directors; INDBOD: the seats of independent directors/total number of board directors; BSHOLD: the number of shares held by directors and supervisors/the number of outstanding shares at the end of the year; ISHOLD: including four categories, i.e., dealers, domestic and foreign fund-raising, the country's trust funds, and foreign institutional investors (foreign investors); DEV: the difference between control rights and cash flow rights; SIZE: the natural log of the company's total assets; AGE: the number of years the company had an establishment; DEBT: total liabilities/total assets; PROFIT: net profit before tax/net revenue in the current period; R&D: R&D expenditure in the current period/net sales in the current period.*

Table 5: Descriptive Statistics - R&D Efficiency

| Variable | Number of Samples | Mean | Median | Standard Deviation | Maximum | Minimum |
|---|---|---|---|---|---|---|
| **Dependent Variable** | | | | | | |
| RD EFFICIENCY | 3,761 | 2.051 | 0.250 | 7.750 | 133.597 | 0.000 |
| **Independent Variable** | | | | | | |
| BOARDSIZE | 3,761 | 7.110 | 7.000 | 1.607 | 15.000 | 2.000 |
| DUALITY | 3,761 | 0.40 | 0.000 | 0.491 | 1.000 | 0.000 |
| OUTBOD | 3,761 | 49.700 | 50.000 | 19.150 | 100.000 | 0.000 |
| INDBOD | 3,761 | 32.416 | 33.333 | 12.921 | 80.000 | 0.000 |
| BSHOLD | 3,761 | 21.130 | 17.090 | 14.710 | 96.46 | 0.010 |
| ISHOLD | 3,761 | 36.149 | 33.790 | 22.019 | 96.950 | 0.000 |
| DEV | 3,761 | 6.978 | 1.650 | 12.458 | 93.550 | 0.000 |
| **Control Variable** | | | | | | |
| SIZE | 3,761 | 15.191 | 15.006 | 1.443 | 21.949 | 9.830 |
| AGE | 3,761 | 25.03 | 24.00 | 10.010 | 65.000 | 2.000 |
| DEBT | 3,761 | 38.634 | 37.711 | 17.292 | 99.760 | 0.904 |
| PROFIT | 3,761 | 0.024 | 0.062 | 0.691 | 12.233 | -21.902 |
| R&D | 3,761 | 0.069 | 0.038 | 0.132 | 3.294 | 0.000 |

*RD EFFICIENCY: The sum of patent rights in the current period and the past two years/the sum of R&D expenditures in the current period and the past two periods (the natural log); BOARDSIZE: the total number of director seats on the board of directors; DUALITY: This variable is a dummy variable, 1 when the chairman and general manager are the same people, otherwise 0; OUTBOD: the number of outside directors/total number of board directors; INDBOD: the seats of independent directors/total number of board directors; BSHOLD: the number of shares held by directors and supervisors/the number of outstanding shares at the end of the year; ISHOLD: including four categories, i.e., dealers, domestic and foreign fund-raising, the country's trust funds, and foreign institutional investors (foreign investors); DEV: the difference between control rights and cash flow rights; SIZE: the natural log of the company's total assets; AGE: the number of years the company had an establishment; DEBT: total liabilities/total assets; PROFIT: net profit before tax/net revenue in the current period; R&D: R&D expenditure in the current period/net sales in the current period.*

## Pearson Correlation Coefficient Analysis

In general, regression models should be based on correlation analysis because the reliability of any interpretation and prediction depends on the strength between the independent and dependent variables. In order to avoid the problem of collinearity among the independent variables during the regression analysis in this study, which will affect the interpretive ability of the variables. This study first used the Pearson correlation coefficient to analyze whether there is a correlation between the variables. The Pearson correlation coefficient is suitable for describing the linear relationship between two continuous variables. It mainly measures the high or low degree of correlation between the variables and does not examine the impact of (independent variable) on (dependent variable). If the correlation coefficient is greater than 0.8, it is highly correlated, indicating collinearity between the variables; a correlation between 0.4 to 0.8 indicates a moderate correlation, and a correlation coefficient below 0.4 indicates a low correlation. In this study, the Pearson correlation coefficients of the variables are arranged in Table 6 to Table 8, except for the multiplication term and related variables. Most of the other independent variables are between plus and minus 0.4, which is a low correlation. Overall, there is no collinearity between the independent variables.

Table 6: Pearson Correlation Coefficient Analysis - R&D Productivity

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) RD PRO | 1 | | | | | | | | | | | |
| (2) BOARSIZE | 0.096*** | 1 | | | | | | | | | | |
| (3) DUALITY | 0.045*** | 0.119*** | 1 | | | | | | | | | |
| (4) OUTBOD | 0.025 | 0.127*** | 0.055*** | 1 | | | | | | | | |
| (5) INDBOD | 0.093*** | 0.033** | -0.019 | 0.546*** | 1 | | | | | | | |
| (6) BSHOLD | 0.093*** | -0.024 | 0.052*** | 0.141*** | 0.014 | 1 | | | | | | |
| (7) ISHOLD | 0.072*** | 0.198*** | 0.158*** | 0.197*** | 0.092*** | 0.347*** | 1 | | | | | |
| (8) DEV | 0.050*** | 0.115*** | 0.131*** | 0.216*** | 0.051*** | 0.531*** | 0.356*** | 1 | | | | |
| (9) OUTBOD ×BSHOLD | 0.088*** | 0.040** | 0.070*** | 0.528*** | - | 0.864*** | 0.390*** | 0.554*** | 1 | | | |
| (10) OUTBOD ×DEV | 0.038** | 0.104*** | 0.126*** | 0.326*** | - | 0.522*** | 0.346*** | 0.959*** | 0.623*** | 1 | | |
| (11) INDBOD ×BSHOLD | 0.029* | 0.028* | 0.062*** | - | 0.457*** | 0.833*** | 0.323*** | 0.463*** | - | - | 1 | |
| (12) INDBOD ×DEV | 0.067*** | 0.102*** | 0.120*** | - | 0.224*** | 0.486*** | 0.331*** | 0.920*** | - | - | 0.568*** | 1 |

**, **, and *** Indicate statistical significance levels of 10%, 5%, and 1%, respectively BOARDSIZE: the total number of director seats on the board of directors; DUALITY: this variable is a dummy variable, 1 when the chairman and general manager are the same people, otherwise 0; OUTBOD: the number of outside directors/total number of board directors; INDBOD: the seats of independent directors/total number of board directors; BSHOLD: the number of shares held by directors and supervisors/the number of outstanding shares at the end of the year; ISHOLD: including four categories, i.e., dealers, domestic and foreign fund-raising, the country's trust funds, and foreign institutional investors (foreign investors); DEV: the difference between control rights and cash flow rights.*

Table 7: Pearson Correlation Coefficient Analysis - R&D Efficiency

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) RD EFF | 1 | | | | | | | | | | | |
| (2) BOARSIZE | 0.190*** | 1 | | | | | | | | | | |
| (3) DUALITY | 0.052*** | 0.121*** | 1 | | | | | | | | | |
| (4) OUTBOD | 0.048*** | 0.128*** | 0.053*** | 1 | | | | | | | | |
| (5) INDBOD | 0.088*** | 0.036** | 0.020 | 0.544*** | 1 | | | | | | | |
| (6) BSHOLD | 0.133*** | 0.027 | 0.049*** | 0.143*** | 0.014 | 1 | | | | | | |
| (7) ISHOLD | 0.194*** | 0.196*** | 0.156*** | 0.196*** | 0.092*** | 0.349*** | 1 | | | | | |
| (8) DEV | 0.017 | 0.115*** | 0.131*** | 0.214*** | 0.051*** | 0.526*** | 0.352*** | 1 | | | | |
| (9) OUTBOD ×BSHOLD | 0.111*** | 0.037** | 0.065*** | 0.528*** | - | 0.865*** | 0.391*** | 0.545*** | 1 | | | |
| (10) OUTBOD ×DEV | 0.027 | 0.105*** | 0.125*** | 0.324*** | - | 0.517*** | 0.342*** | 0.959*** | 0.613*** | 1 | | |
| (11) INDBOD ×BSHOLD | 0.089*** | 0.031*** | 0.061*** | - | 0.457*** | 0.829*** | 0.322*** | 0.461*** | - | - | 1 | |
| (12) INDBOD ×DEV | 0.002 | 0.102*** | 0.120*** | - | 0.224*** | 0.482*** | 0.327*** | 0.920*** | - | - | 0.565*** | 1 |

**, **, and *** Indicate statistical significance levels of 10%, 5%, and 1%, respectively BOARDSIZE: the total number of director seats on the board of directors; DUALITY: this variable is a dummy variable, 1 when the chairman and general manager are the same people, otherwise 0; OUTBOD: the number of outside directors/total number of board directors; INDBOD: the seats of independent directors/total number of board directors; BSHOLD: the number of shares held by directors and supervisors/the number of outstanding shares at the end of the year; ISHOLD: including four categories, i.e., dealers, domestic and foreign fund-raising, the country's trust funds, and foreign institutional investors (foreign investors); DEV: the difference between control rights and cash flow rights*

Table 8: Pearson Correlation Coefficient Analysis – Patent Productivity

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) PATENT PRO | 1 | | | | | | | | | | | |
| (2) BOARSIZE | 0.130*** | 1 | | | | | | | | | | |
| (3) DUALITY | 0.045** | 0.133*** | 1 | | | | | | | | | |
| (4) OUTBOD | 0.014 | 0.179*** | 0.092*** | 1 | | | | | | | | |
| (5) INDBOD | 0.043** | 0.076*** | 0.018 | 0.536*** | 1 | | | | | | | |
| (6) BSHOLD | 0.074*** | 0.018 | 0.050** | 0.148*** | 0.011 | 1 | | | | | | |
| (7) ISHOLD | 0.154*** | 0.265*** | 0.185*** | 0.229*** | 0.090*** | 0.290*** | 1 | | | | | |
| (8) DEV | 0.068*** | 0.099*** | 0.127*** | 0.238*** | 0.050*** | 0.613*** | 0.357*** | 1 | | | | |
| (9) OUTBOD ×BSHOLD | 0.061*** | 0.058*** | 0.084*** | 0.526*** | - | 0.869*** | 0.361*** | 0.629*** | 1 | | | |
| (10) OUTBOD ×DEV | 0.051*** | 0.086*** | 0.128*** | 0.349*** | - | 0.603*** | 0.351*** | 0.959*** | 0.701*** | 1 | | |
| (11) INDBOD ×BSHOLD | 0.037* | 0.038* | 0.051** | - | 0.427*** | 0.847*** | 0.255*** | 0.548*** | - | - | 1 | |
| (12) INDBOD ×DEV | 0.080*** | 0.080*** | 0.117*** | - | 0.221*** | 0.567*** | 0.326*** | 0.926*** | - | - | 0.648*** | 1 |

**, **, And *** Indicate Statistical Significance Levels Of 10%, 5%, And 1%, Respectively BOARDSIZE: The Total Number Of Director Seats On The Board Of Directors; DUALITY: This Variable Is A Dummy Variable, 1 When The Chairman And General Manager Are The Same People, Otherwise 0; OUTBOD: The Number Of Outside Directors/Total Number Of Board Directors; INDBOD: The Seats Of Independent Directors/Total Number Of Board Directors; BSHOLD: The Number Of Shares Held By Directors And Supervisors/The Number Of Outstanding Shares At The End Of The Year; ISHOLD: Moderating; DEV: The Difference Between Control Rights And Cash Flow Rights*

Regression Analysis Results

Firstly, this study explores the impact of corporate board composition on innovation performance. Table 9 presents the empirical results for H1a, H1b, H1c, and H1d. The results show that the board of directors' size (BOARDSIZE) and the ratio of independent directors (INDBOD) have a significant positive correlation with the model (2), indicating that the larger the board of directors' size and the higher the ratio of independent directors, the better the investment in the company's R&D innovation, which supports the hypothesis H1a and H1d. However, they have a significant negative correlation with the model (1), indicating that when the board of directors' size is larger, and the ratio of independent directors is higher, it may be due to the difficulty in integrating team opinions or because it is more difficult for independent directors to obtain internal company information, thus having a negative impact on the company's final output (sales), which is incompatible with H1a. In addition, the chairman and general manager (DUALITY) have a significant positive correlation with model (1), which does not support hypothesis H1b. The results show the contrary to agency theory, i.e., when the chairman is also the general manager, the unification of the command and order system is beneficial to the company's positive impact on the final output.

In terms of control variables, company size (SIZE) is positively correlated with model (2) but negatively correlated with the model (1) and (3), indicating that the larger the company is, the more beneficial it is to R&D investment but not conducive to final output. The company age (AGE) has a significant positive correlation with the models (1) and (3), indicating that the longer a company has been in the establishment, the more beneficial it is to the final output (sales) of R&D innovation. Debt ratio (DEBT) has a significant positive correlation with model (1), indicating that creditors have a supervisory effect on the results of innovation activities. Profitability (PROFIT) and R&D intensity (R&D) are significantly negatively correlated, which means that higher values will not have a good impact on innovation performance.

Table 9: The Impact of Board Composition on Innovation Performance

| | (1)-R&D Productivity | | (2)-R&D Efficiency | | (3)-Patent Productivity | |
|---|---|---|---|---|---|---|
| | **Coefficient** | **t** | **Coefficient** | **t** | **Coefficient** | **t** |
| Constant | 1.658*** | 52.422 | -42.183*** | -29.298 | 17.055*** | 16.018 |
| BOARDSIZE | -0.045*** | -2.950 | 0.036** | 2.341 | -0.026 | -1.278 |
| DUALITY | 0.028** | 1.961 | 0.015 | 1.034 | 0.001 | 0.046 |
| OUTBOD | 0.013 | 0.771 | -0.008 | -0.465 | 0.018 | 0.775 |
| INDBOD | -0.036** | -1.996 | 0.101*** | 5.463 | -0.006 | -0.229 |
| SIZE | -0.187*** | -11.813 | 0.503*** | 31.242 | -0.308*** | -14.162 |
| AGE | 0.099*** | 6.627 | -0.011 | -0.741 | 0.155*** | 7.473 |
| DEBT | 0.103*** | 6.682 | -0.024 | -1.546 | -0.030 | -1.432 |
| PROFIT | -0.216*** | -13.057 | -0.009 | -0.548 | -0.060*** | -2.694 |
| R&D | -0.535*** | -31.248 | -0.085*** | 5.255 | -0.177*** | -7.705 |
| YEAR | YES | | YES | | YES | |
| F value | 113.946 | | 99.843 | | 27.278 | |
| $R^2$ | | | | | | |
| Adjusted $R^2$ | 0.283 | | 0.255 | | 0.118 | |

*This table shows the regression analysis results of the impact of corporate board composition on innovation performance. All coefficient values are standardized, only the constant term presents unstandardized values. *, **, and *** Indicate statistical significance levels of 10%, 5%, and 1%, respectively.*

Subsequently, to explore the impact of ownership structure on innovation performance, Table 10 shows the empirical results of H2a, H2b, and H2c. The results show that the correlation between the shareholding ratio of directors and supervisors (BSHOLD) with models (1) and (3) is significantly positive, indicating that when the shareholding ratio of a company's directors and supervisors is higher, it has a good impact on the final output (sales) of R&D innovation, supporting hypothesis H2a. In terms of institutional shareholder ratio (ISHOLD), the results of this study are positive but not significant with the model (3). In terms of control rights and cash flow rights (DEV), the results of this study show that there is a significant negative correlation with models (1) (2) (3), indicating that when the company's DEV is higher, it is not conducive to R&D investment, patent output, and final output (sales), and it is less inclined to innovate activities. This result supports hypothesis H2c. The control variables are not much different from the previous empirical results. However, the research and development intensity (R&D) has a significant positive correlation with the model (2), indicating that when more considerable R&D will have a good impact on the R&D efficiency.

Table 10: The Impact of Ownership Structure on Innovation Performance

| | (1)-R&D Productivity | | (2)-R&D Efficiency | | (3)-Patent Productivity | |
|---|---|---|---|---|---|---|
| | **Coefficient** | **t** | **Coefficient** | **t** | **Coefficient** | **t** |
| Constant | 1.579*** | 49.111 | -39.184*** | -26.849 | 16.724*** | 14.760 |
| BSHOLD | 0.093*** | 4.967 | 0.008 | 0.424 | 0.053** | 1.994 |
| ISHOLD | -0.004 | -0.218 | -0.004 | -0.215 | 0.032 | 1.251 |
| DEV | -0.068*** | -4.031 | -0.039** | -2.256 | -0.071** | -2.859 |
| SIZE | -0.180*** | -9.748 | 0.520*** | 27.669 | -0.319*** | -11.899 |
| AGE | 0.110*** | 7.477 | -0.048*** | -3.203 | 0.154*** | 7.459 |
| DEBT | 0.106*** | 6.838 | -0.029* | -1.872 | -0.026 | -1.213 |
| PROFIT | -0.211*** | -12.793 | -0.006 | -0.387 | -0.061*** | -2.752 |
| R&D | -0.527*** | -30.785 | 0.088*** | 5.399 | -0.173*** | -7.525 |
| YEAR | YES | | YES | | YES | |
| F value | 124.551 | | 103.302 | | 30.316 | |
| $R$ 2 | | | | | | |
| Adjusted $R$ 2 | 0.284 | | 0.246 | | 0.121 | |

*This table shows the regression analysis results of the impact of ownership structure on innovation performance. All coefficient values are standardized, only the constant term presents unstandardized values. *, **, and *** Indicate statistical significance levels of 10%, 5%, and 1%, respectively.*

Table 11 and Table 12 present the empirical results of regression analysis on the impact of board independence on the moderating effect of ownership concentration on innovation performance. The first is the moderating effect of the outside director ratio. The empirical results show that the impact on the outside director's seat (OUTBOD) and the shareholding ratio of directors and supervisors (BSHOLD) have a significant negative correlation with the model (2), indicating that the outside director ratio and the shareholding ratio of directors and supervisors are higher, it is the more unfavorable for the company to conduct R&D innovation. However, after independent directors moderate the shareholdings of directors and supervisors, there is a significant positive correlation with the company's R&D efficiency, consistent with hypothesis H3a. This study concludes that after moderates, it may reduce the information asymmetry, alleviate the disadvantage that outside directors may not be able to obtain information easily, and conduct supervision to develop R&D innovation activities. The moderating effect between the outside director ratio and control rights and cash flow rights (DEV) still negatively correlates with R&D efficiency. Hypothesis H3b is not supported, indicating that outside directors do not mitigate the deviation of the company's control rights and cash flow rights and supervise their R&D innovation activities.

Table 11: The Impact of Board Independence on the Moderating Effect of Ownership Concentration on Innovation Performance

| | (1)-R&D Productivity | | (2)-R&D Efficiency | | (3)-Patent Productivity | |
|---|---|---|---|---|---|---|
| | **Coefficient** | **t** | **Coefficient** | **t** | **Coefficient** | **t** |
| Constant | 1.574*** | 45.773 | -37.788*** | -24.116 | 17.263*** | 14.404 |
| BOARDSIZE | -0.044*** | -2.872 | 0.034** | 2.181 | -0.024 | -1.177 |
| DUALITY | 0.027 | 1.944 | 0.007 | 0.516 | 0.000 | -0.021 |
| OUTBOD | 0.006 | 0.226 | -0.093*** | -3.765 | -0.040 | -1.205 |
| BSHOLD | 0.023 | 0.507 | -0.094** | -2.055 | -0.070 | -1.097 |
| ISHOLD | -0.011 | -0.604 | 0.002 | 0.082 | 0.022 | 0.838 |
| DEV | -0.008 | -0.128 | 0.084 | 1.407 | -0.075 | -0.915 |
| OUTBOD×BSHOLD | 0.093* | 1.705 | 0.133** | 2.444 | 0.163** | 2.098 |
| OUTBOD×DEV | -0.070 | -1.137 | -0.129** | -2.085 | -0.009 | -0.100 |
| SIZE | -0.158*** | -8.206 | 0.505*** | 25.660 | -0.307*** | -11.004 |
| AGE | 0.106*** | 7.178 | -0.038** | -2.521 | 0.151*** | 7.256 |
| DEBT | 0.100*** | 6.464 | -0.025 | -1.571 | -0.027 | -1.289 |
| PROFIT | -0.212*** | -12.819 | -0.007 | -0.434 | -0.056** | -2.524 |
| R&D | -0.528*** | -30.824 | 0.089*** | 5.480 | -0.171*** | -7.386 |
| YEAR | YES | | YES | | YES | |
| F value | 89.412 | | 74.766 | | 21.926 | |
| *R* 2 | | | | | | |
| Adjusted *R* 2 | 0.287 | | 0.250 | | 0.123 | |

*This table shows the regression analysis results of the impact of board independence on the moderating effect of ownership concentration on innovation performance. All coefficient values are standardized, only the constant term presents unstandardized values. *, **, and *** Indicate statistical significance levels of 10%, 5%, and 1%, respectively.*

This study regarded the impact of board independence moderating the ownership concentration on innovation performance. Subsequently, this study analyzes the moderating effect of the independent director ratio (INDBOD). The empirical results show that the independent director's seat and the shareholding ratio of directors and supervisors have a significant positive correlation with model (2). They indicated that when the independent director ratio and the shareholding ratio of directors and supervisors are higher, it is beneficial for the company to conduct R&D innovation. However, after independent directors moderate the directors' shareholdings and supervisors, they present a significant negative correlation, which is not beneficial to the company's R&D innovation activities. It does not support hypothesis H3c. In addition, after the ratio of independent directors moderates the degree of deviation of control rights and cash flow rights, it presents a significant positive correlation with R&D efficiency. Supporting hypothesis H3d shows

that the independent directors have professional background and independence, fulfilling their supervisory and management responsibilities and providing opinions for R&D innovation decision-making so that companies' innovation performance can be improved.

Table 12: The Impact of Independent Director Ratio on Innovation Performance

| | R&D Productivity | | R&D Efficiency | | Patent Productivity | |
|---|---|---|---|---|---|---|
| | **Coefficient** | **t** | **Coefficient** | **t** | **Coefficient** | **t** |
| Constant | 1.592*** | 44.939 | -44.841*** | -28.093 | 16.924*** | 13.604 |
| BOARDSIZE | -0.042*** | -2.767 | 0.039*** | 2.576 | -0.024 | -1.157 |
| DUALITY | 0.026* | 1.824 | 0.007 | 0.488 | -0.001 | -0.059 |
| INDBOD | -0.010 | -0.428 | 0.196*** | 7.967 | 0.001 | 0.037 |
| BSHOLD | 0.154*** | 3.327 | 0.227*** | 5.014 | 0.061 | 0.914 |
| ISHOLD | 0.002 | 0.094 | -0.013 | -0.692 | 0.033 | 1.250 |
| DEV | -0.077 | -1.631 | -0.179*** | -3.811 | -0.004 | -0.063 |
| INDBOD×BSHOLD | -0.077 | -1.517 | -0.258*** | -5.165 | -0.010 | -0.138 |
| INDBOD×DEV | 0.016 | 0.342 | 0.152*** | 3.167 | -0.071 | -0.998 |
| SIZE | -0.164*** | -8.562 | 0.513*** | 26.423 | -0.311*** | -11.185 |
| AGE | 0.097*** | 6.377 | -0.016 | -1.065 | 0.147*** | 6.862 |
| DEBT | 0.102*** | 6.561 | -0.025 | -1.636 | -0.027 | -1.253 |
| PROFIT | -0.213*** | -12.899 | -0.008 | -0.521 | -0.061*** | -2.731 |
| R&D | -0.528*** | -30.858 | 0.084*** | 5.167 | -0.173*** | -7.520 |
| YEAR | YES | | YES | | YES | |
| F value | 89.572 | | 78.961 | | 21.608 | |
| $R^2$ | | | | | | |
| Adjusted $R^2$ | 0.288 | | 0.261 | | 0.121 | |

*This table shows the regression analysis results of the impact of the independent director ratio on innovation performance. All coefficient values are standardized, only the constant term presents unstandardized values. *, **, and *** Indicate statistical significance levels of 10%, 5%, and 1%, respectively.*

## CONCLUDING COMMENTS

Nowadays, technology is changing rapidly, and fierce competition has shortened the life cycle of many industries, such as high-tech industries. If a company wants to survive in this globalization trend, it must create advantages through continuous R&D innovation. Therefore, in responding to changes in the environment, managers' strategies and directions are also the keys to success or failure. There may be traditional or core agency problems when companies have information asymmetry. Since most companies in Taiwan are family businesses, their equity is relatively concentrated, which may lead to core agency problems. Currently, the board of directors plays a crucial role in determining how to avoid agency problems that internal and external mechanisms of corporate governance need to mitigate. This study uses a sample based on Taiwan's listed OTC electronics companies from 2014 to 2018 to explore the impact of board composition and ownership structure on companies' innovation performance.

The results of this study found that the influence of the measurement variables of board composition and ownership structure on R&D investment and sales is not consistent. It may be because management decisions and outside director opinions are beneficial to the company's R&D innovation. However, it is detrimental to the final output (sales). Outside directors can successfully adjust the shareholding of directors and supervisors, effectively improving the company's innovation performance. In contrast, independent directors can positively moderate the degree of deviation in control rights and cash flow rights, which improves the company's R&D efficiency. This study aims to explore the impact of board composition and ownership structure on companies' innovation performance, and it also explores whether independent directors and outside directors can moderate the phenomenon of ownership concentration and positively impact companies. In Taiwan, most companies are family businesses with ownership concentration and

control rights, and then the cash flow rights deviation is a normal phenomenon. In response to changes in the environment, companies may carry out R&D innovation activities that are high-risk and require a large amount of expenditure. Therefore, corporate governance is needed to check and balance the self-interested behavior of controlling shareholders, which may infringe on the behavior of other small shareholders.

This study suggests that when companies conduct R&D innovation, they disclose information appropriately and reduce information asymmetry so that minority shareholders and external directors, including independent directors, can effectively supervise. Timely opinions and R&D innovation by the company have a positive impact, allowing the company to develop and operate sustainably in a competitive environment.

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