Doctoral Dissertation

INTERRELATIONSHIP BETWEEN INNOVATION (PATENTING STRATEGY) AND FINANCING BEHAVIOR: AN EMPIRICAL ANALYSIS OF JAPANESE FIRMS

(イノベーション(特許戦略)とファイナンシングの相互関係：日本企業の実証分析)

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DECLARATION OF AUTHORSHIP

I, Le Thuy Ngoc An, hereby affirm that the thesis entitled "Interrelationship between Innovation (Patenting Strategy) and Financing Behavior: An Empirical Analysis of Japanese Firms" is my original work, and it has not been submitted for any degree or diploma in any other university. To the best of my knowledge and belief, this dissertation does not contain any material that has been previously published or written by another person, except where proper reference is provided within the dissertation itself.

Le Thuy Ngoc An　　　　　　　　　　　　Date: 18 February, 2024

DEDICATION

This dissertation is lovingly dedicated to my husband, Narimasa Kumagawa, and my parents, Lê Ngọc Bình and Trần Thị Thuỷ. Their unwavering encouragement, support, and assistance have been my guiding light throughout my academic journey.

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This dissertation acknowledgement is a tribute to all the people who made my academic journey worthwhile.

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ABSTRACT

In the dynamic global business landscape, finance and innovation stand as the twin pillars of corporate success. Both finance and innovation are vital for a company's long-term viability, demanding a harmonious interplay between prudent financial management and a culture that fosters innovation. Research in the field examining the relationship between a firm's finance and innovation is rapidly growing, offering profound insights into the dynamics shaping organizational success. While many empirical studies traditionally presumed that financial support drives innovative efforts, alternative perspectives support the reverse causation hypothesis, suggesting that innovation can stimulate financial performance. The current corporate management research often takes a segmented approach, focusing on either the signaling effect of innovation on financial performance or the influence of finance on innovation performance. While insightful, this segmented approach resembles examining separate puzzle pieces without considering the whole picture.

We contend that finance and innovation are mutually interdependent, influencing each other. Our study uniquely explores both dimensions, investigating how financial resources stimulate innovation, and how innovation, primarily represented by patents, attracts investors and secures financial support. Focusing on Japanese corporations, our research provides a distinctive perspective due to Japan's diverse business landscape, strong patent system, and commitment to innovation. Japan's risk-averse market and global competition highlight the importance of innovation and the role of patents as signals for economic growth.

The first study scrutinizes the intricate relationship between financial resources and firms' innovation outputs, exploring the influence of various financing sources, internal and external, inspired by the Pecking Order Theory. It involves a sample of 113 Japanese manufacturing firms listed on the JASDAQ market, using patent-based metrics to gauge technological innovation. The study highlights the crucial roles played by both internal and external financial resources in driving innovation outputs. Firms demonstrate a strong preference for self-generated financing, particularly internal funding. Additionally, the research unveils the complementary impact of debt financing, especially when internal resources are depleted, aligning with the Pecking Order Theory's risk principles.

In our second study, we explore the reverse causation between innovation and finance, particularly during initial public offerings (IPOs). IPOs are pivotal, as they provide capital for growth and enhance a firm's reputation. However, information asymmetry poses a challenge, leading investors to rely on quality signals. We hypothesize that patents, as a proxy for innovation, mitigate information asymmetry because their information is verifiable, observable, and entails maintenance costs. Thus, a company with numerous patents before an IPO is likely to gain investor trust, leading to a more successful IPO. We analyze 338 newly listed Japanese firms across various industries, finding robust positive correlations between pre-IPO patent applications and IPO financial performance. This contribution enriches the literature on the impact of patents on IPO performance and illuminates the broader influence of innovation on finance.

The third study delves into the dynamics of patent signaling within IPO firms, distinguishing between high-tech and low-tech sectors. High-tech firms often face more information asymmetry, with less transparency in R&D and patent disclosures, making them riskier for investors. Low-tech firms, with valuable patents and balanced resource allocation, are more accessible to investors. This raises the question of whether high-tech firms are less successful in using patent signals to raise total capital during the IPO process, as previous research has mainly focused on high-tech firms in technology-intensive markets. While prior studies often grouped all IPOs together or concentrated on specific industries, our study adds fresh insights to the entrepreneurship and innovation landscape by asserting that patents exert a more substantial influence on IPO success for low-tech companies in comparison to their high-tech counterparts. This observation underscores the necessity for an in-depth exploration of the patent signaling mechanism in IPOs, especially for low-tech firms characterized by simpler innovation portfolios and tangible assets appealing to risk-averse investors.

Overall, our dissertation offers a comprehensive exploration of the interplay between finance and innovation in Japanese corporations, providing nuanced insights into the implications of this symbiotic relationship for businesses, policymakers, and scholars worldwide.

Keywords: Finance, innovation, IPO, Japanese companies

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EXPLAINATION OF IMPORTANT TERM IN THE THESIS

TERM	EXPLAINATION
Initial Public Offering (IPO)	IPO refers to process of offering shares of a private corporation to the public in a new stock issuance for the first time. An IPO allows a company to raise equity capital from public investors. An IPO is a big step for a company as it provides the company with access to raising a lot of money. This gives the company a greater ability to grow and expand. The increased transparency and share listing credibility can also be a factor in helping it obtain better terms when seeking borrowed funds as well. Meanwhile, it also allows public investor to participate in the offering
Information Asymmetry	Also known as "information failure", occurs when one party to an economic transaction possesses greater material knowledge than the other party. This issue with asymmetric information starts before any transaction take place and the asymmetric information exists everywhere, making flawless business agreements and transactions almost impossible to come by
Pecking Order Theory	Also known as the Pecking Order Model, relates to a company's capital structure. The theory states that managers follow a hierarchy when considering source of financing. The pecking order theory state that managers display the following preference of sources to fund investment opportunities: first, through the company's internal source, followed by debt and choosing equity financing as a last resort
JASDAQ	The Jasdaq is a stock exchange in Japan focuses on emerging companies. It is one of several subsidiaries of Japan Exchange Group

CHAPTER I: INTRODUCTION

1.1. Research Problem and Research Objective:

In the dynamic and ever-evolving global business landscape, finance and innovation emerge as the twin pillars of corporate success. The significance of these factors is undeniable as they have interdependent and mutually reinforcing effects on a company's competitive edge, potential for expansion, and overall operational outcomes. Finance is often regarded as the lifeblood of any business.It offers the fundamental resources needed for investing in expansion plans, managing financial risks, and carrying out daily operations (Pandey, 2017). A corporation with sufficient financial resources can pay its workers, satisfy its short-term commitments, and maintain operations (Adeyanju, 2011). Financial resources enable a company to diversify its operations and investments. This diversification not only reduces risk by spreading exposure across various markets but also opens up new avenues for innovation. A well-financed company can explore new markets, invest in research and development, and take calculated risks that can lead to innovative breakthroughs (Hall, 2010).

While finance ensures the survival of a company, innovation is the driving force behind its growth and relevance in a rapidly changing business landscape. Innovation encompasses the development of new products, services, processes, and business models that differentiate a company from its competitors (Teece, 2010). It allows a company to adapt to evolving customer preferences, market dynamics, and technological advancements. Innovation, fueled by financial support, can confer a significant competitive advantage. Innovations can range from groundbreaking technological advances to incremental improvements in efficiency and customer experience . Companies that continuously innovate are better positioned to capture market share, command higher prices for their products or services, and establish themselves as industry leaders (K. Z. Zhou et al., 2009).

Both finance and innovation contribute to the long-term sustainability of a company. While finance ensures short-term stability, innovation secures the company's relevance in the future. A successful company strikes a balance between managing its finances prudently and fostering a culture of innovation that keeps it ahead of the competition. Apple and Tesla, two prominent tech companies, exemplify how finance and innovation are intertwined. Apple's financial strength allows substantial investments in research and development, resulting in groundbreaking products protected by patents. Similarly, Tesla's access to financing, particularly venture capital and public funding, has driven innovations in electric vehicles and energy solutions, supported by a strong patent portfolio. Both companies showcase the synergy between financial resources and innovative success. Since both innovation and finance are the importance factors to the success of an organization, research in the field of relationship between firm's finance and its innovation was actively evolving. This field is of paramount importance because it sheds light on the complex relationship between financial decisions, innovation activities, and their ultimate impact on a firm's performance.

However, previous study in the field of corporate finance has often taken a segment approach, focusing on singular aspects of the intricate relationship between finance and innovation. The majority of these research have divided their attention into two areas: the signal effect of innovation on financial performance, or the influence of finance on innovation performance. Although insightful, this divided viewpoint has been a little like looking at separate parts of a jigsaw puzzle without taking the whole picture into account.

Current literatures have highlighted the relationship between financial development and innovation, showcasing how various aspects of financial systems, such as external finance, banking sector growth, stock market development, and financial structure, influence innovation outcomes across different countries and regions. For instance, (Le et al., 2019) categorized financial development into bank-based and stock-market-based domains and investigated their impact on innovation. Their study, spanning 25 Asian countries from 2000 to 2015 and using the two-step Generalized Method of Moments, compellingly demonstrates that financial development promotes innovation, with particular emphasis on banking sector and stock market growth leading to increased patent applications. Concentrate in emerging markets, (Kapidani & Luci, 2019) explored the connection between financial development indicators and innovation across 15 developing countries from 1996 to 2016. Their findings reveal a positive correlation between higher crediting by the banking sector and increased patent applications. In addition, (Trinugroho et al., 2021) investigated the impact of financial structure on innovation using manufacturing data spanning 59 countries or regions from 1996 to 2015. Their empirical evidence underscores that market-based financial structures significantly foster innovation in advanced economic development settings within the industry.

Much of the empirical work on the relationship between a firm's financing and innovation assumes the common wisdom that the direction of causality goes from finance to innovation. However, there is room to believe that the opposite may be at work, given that when innovative projects are able to open up opportunities, there could be a demand for specific financial instruments, thus affecting a firm's financial performance. Recent studies also have placed considerable emphasis on the pivotal role of innovation in shaping a firm's access to financing and its financial performance. In particular, the literature underscores how patents, serving as proxies for innovation, function as valuable assets that extend well beyond mere legal protections, profoundly impacting a firm's ability to secure capital and its overall financial performance. For example, (Audretsch et al., 2012) assert that emerging innovative ventures employ patents to signal their ability to protect intellectual property rights and prototypes to demonstrate the feasibility of their ideas to potential investors. Empirical data from 906 high-tech startups in the U.S. shows that ventures with patents and prototypes are more likely to secure equity finance. In the bio-pharmaceutical sector in China, research of (L. Zhang et al., 2019) underscores the pivotal role of patents in venture capital funding. In essence, aligning with previous literature, this research reaffirms that venture capital financing decisions among Chinese venture capitalists are profoundly influenced by patent signals. (Czarnitzki et al., 2014) explore how patents affect financing constraints for established U.S. firms in R&D. Their findings highlight that patents alleviate financing issues, particularly for smaller firms with information gaps and limited collateral value.

What we observe from the existing literature is that current studies predominantly focus on two separate areas: the impact of innovation on financial performance and the influence of finance on innovation performance. Therefore, our study aims to bridge this gap by simultaneously exploring both dimensions, striving to achieve a comprehensive understanding of their intricate interactions. Finance and innovation are interdependent, and our research aims to uncover how financial resources catalyze innovation while investigating the signal effect of innovation, notably through patents, in attracting investors and securing financial support. By delving into the impact of finance on innovation, we aim to unravel the mechanisms through which financial resources can serve as catalysts for innovative endeavors, a pivotal factor in long-term corporate success. Simultaneously, we investigate the signal effect of innovation, particularly through indicators like patents, in attracting investors and securing financial support. This dual perspective is not only instrumental in guiding businesses in optimizing their financial strategies to fuel innovation efforts but also informs policymakers and stakeholders in their pursuit of innovation-led economic growth. Furthermore, our choice to concentrate on Japanese corporations adds an extra layer of distinctiveness to our research. Japan's diverse business landscape, blending established conglomerates with agile startups, offers a rich context to explore the multifaceted relationship between finance and innovation. Japan's robust patent system and commitment to innovation provide a precise lens to assess innovation's impact on financial performance. Additionally, Japan's risk-averse market and intense global competition underscore the importance of innovation for economic growth, emphasizing the effectiveness of patents as signals in such an environment. In essence, our research takes a holistic approach, examining the interplay between finance and innovation in Japanese corporations. We aspire to provide nuanced insights into this symbiotic relationship's implications for businesses, policymakers, and scholars worldwide. Our study's layout and flow will be discussed in detail as follow.

In Chapter 3, we introduce our first paper, which delves into how financial sources influence a firm's innovation output within the Japanese market. Chapter 4 investigates the signal effect of pre-IPO innovation on a company's financial performance during IPOs in Japan. Moving on to Chapter 5, we delve even deeper into the link between innovation and financial performance. Our primary focus is on unraveling the intricate relationship between patents and the financial performance of Japanese companies during the IPO stage, with a specific emphasis on understanding how this relationship can vary depending on the technology intensity level of the firm. By considering both financial choices and innovation initiatives, particularly patent performance, we enrich the global discourse on finance-innovation dynamics, offering methodological advancements and practical insights for informed decision-making by stakeholders in a dynamic corporate landscape.

1.2. Research Questions:

1.2.1. Chapter 3: Financial sources and firm's innovation output: analysis of JASDAQ market

Innovation output extends beyond discoveries and inventions to encompass a range of corporate activities that significantly impact economic factors, such as sales, profitability, productivity, and asset value (Kemp et al., 2003). Recognizing innovation's pivotal role in a firm's long-term competitiveness, a growing body of literature seeks to understand the key drivers of a company's innovation success. Among the key factors that affect the success of a company's innovation, financial resources are widely acknowledged as essential for the survival of innovative firms (Hall, 2010; Magri, 2009; Vermeulen, 2005). This realization is not surprising, given that innovation is a multifaceted process that involves extensive research and development, prototyping, testing, and eventual market launch. All of these activities require significant financial investments. A company's ability to allocate the necessary resources to these endeavors can make or break its innovation initiatives.

Financial resources come from both internal and external sources. Internal financing comprises funds generated from a company's operations, such as retained earnings and free cash flows (Almeida & Campello, 2010). External financing includes sources like loans, equity investments, and bonds, where the company seeks capital from external entities (Javakhadze et al., 2016). In the arena of innovation, a well-structured financial strategy ensures that a company has the necessary resources to drive innovation, which, in turn, can enhance its competitiveness and sustainability in a rapidly evolving business landscape. However, what's particularly intriguing is how this dynamic varies between established, larger firms and younger, smaller enterprises.

The existing body of research has primarily focused on assessing the impact of financial sources in the context of large and well-established firms (Armenter & Hnatkovska, 2017; Clarke et al., 2012; Elsas et al., 2004). Established firms, backed by a history of financial stability and substantial cash reserves, have greater access to diverse financing options. They typically employ a combination of internal and external sources, encompassing retained earnings, debt financing, and issuing shares. These companies can tap into external funding for various innovation phases, from early research and development to later stages like production and marketing. They might prioritize external financing when substantial investments promise commensurate returns.

On the contrary, the literature has paid minimal attention to the effects of finance on innovation output in young and small enterprises. We argue that junior stock markets, known for their less stringent listing requirements compared to established stock exchanges, tend to attract many young and rapidly growing firms, especially in countries like Japan. These firms listed on junior markets often have significant growth potential through innovative activities, necessitating substantial financing, particularly for research and development (R&D). However, despite their promising growth prospects, young and innovative firms frequently face challenges in securing external funding. The high level of uncertainty in their business prospects makes external capital providers, including banks and investors, reluctant to invest in these firms. In such cases, these young firms typically follow the Pecking Order Theory, as elucidated by (Myers & Majluf, 1984). This theory outlines a financing hierarchy that managers usually adhere to when funding investments and projects. It begins with internal or self-financing, which is the least risky and includes sources like free cash flows and retained earnings.

External sources, such as loans and issuing shares, come into play only when internal funds are exhausted. Among debt financing and equity financing of external sources, young and small firms often turn to debt financing. This shift towards debt financing is driven by the consistent and reliable funding that banks provide without requiring firms to give up ownership. The reasoning behind this approach is that innovation typically takes years to generate returns, making it less aligned with the short-term profit goals of equity investors.

As a result, firms are more inclined to use debt financing for innovation to address the misalignment of investment objectives.

In this study, our focus lies on the selection of a sample comprised of young, smaller firms listed on the JASDAQ market. These firms are distinguishable by their comparatively modest market capitalizations, as well as their limited operational history and experience. We propose that these smaller and younger firms often contend with internal financing constraints while harboring a prudent aversion to risk. Combined with the ever-present uncertainty associated with innovation, they typically prioritize financing from internal sources, such as cash flows, over external alternatives like debt. Equity financing is often considered a last resort. A graphical representation of our research framework is provided in Figure 1.1 to elucidate the primary concepts underpinning our investigation.

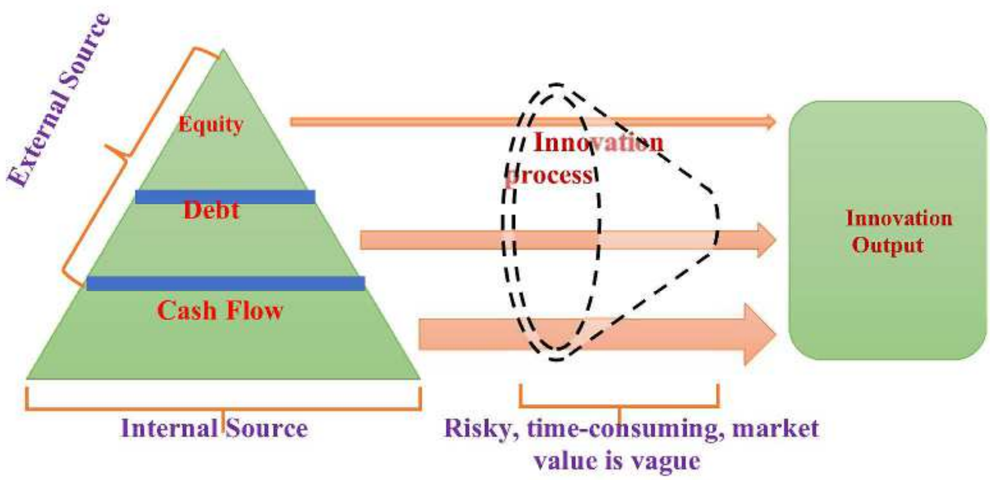


Figure 1.1 Primary research framework for chapter III

The main research question in this chapter revolves around the determinants of innovation outputs in small and young firms, leveraging the Pecking Order theory. This has prompted the formulation of several sub-questions:

- Are innovation outputs, such as patents application, publication, and citation, positively influenced by firms' internally generated source of financing (cash flow)?

- Are innovation outputs positively influenced by the proportion of firms' debt to equity ratio?

- Are innovation outputs influenced by the hierarchy of financial sources, moving from internal financing to external sources?

- Are innovation outputs influenced by the hierarchy in external financial sources, shifting from debt to equity?

1.2.2. Chapter 4: Impact of patent signal on firm's performance at IPO: An empirical analysis of Japanese firms

In Chapter 3, we delved into the impact of financial structure on innovation output for small and young Japanese firms. It's essential to recognize that finance and innovation share a mutually influential relationship, with each exerting a complex set of influences on the other. In this chapter, we'll shift our focus to explore the reverse causation of the innovation-financial relationship. Specifically, we'll examine how innovation affects a company's financial performance as IPO event.

IPO is pivotal for a company, especially in financial terms. It brings an infusion of capital as the company's shares are made available to the public. This capital can be used for various purposes, from expansion to research and development. An IPO also enhances the company's reputation, making it more appealing to investors, partners, and customers (Draho, 2004). Additionally, it allows early investors to realize the value of their investments and provides the opportunity to use company stock for acquisitions. In essence, an IPO can significantly boost a company's financial standing, grant access to capital markets, and foster growth and innovation(Chin et al., 2006).

However, the path to an IPO is challenging, and one significant hurdle is the presence of information asymmetry. In the lead-up to the IPO, a company often possesses detailed knowledge about its operations, financial health, and growth prospects that is not readily available to external stakeholders, including potential investors. This information gap can create uncertainty and complexity in the valuation of the company. It is difficult for investors to understand the specialized technologies and cutting-edge knowledge of the firms. Besides, given that the majority of companies lack steady operations, earnings, and liquidity, it is challenging for external investors to determine their real value. Consequently, investors depend on a company's quality signals, such as the company's strategies and decisions, the specific characteristics of the firm, or behaviors that might indicate its future potential (Bergh et al., 2014; B. D. Cohen & Dean, 2005; Connelly et al., 2011) Researchers have identified a number of indicators that act as quality signals for the firms, such as third-party affiliations like venture capital-backed companies, investment bankers, business partners, underwriters, CEOs, and the top management team.

While previous research has primarily focused on patent signaling in specific sectors and regions, there's been limited attention to whether patents continue to serve as a signal for companies in various industries when pursuing IPOs. Moreover, the Japanese market, known for its risk-averse investors, hasn't been extensively studied in this context. In current research, we aim to investigate the significance of patent signals to IPO success in the Japanese market across diverse industry sectors, shedding light on the role of patents in mitigating information asymmetry and enhancing the success of IPOs. We posit that the more patents a company has before its IPO is positively correlated with better IPO performance, especially in terms of capital obtained from investors. A graphical representation of our research framework is provided in **Figure 1.2** to elucidate the primary concepts underpinning our investigation.

Figure 1.2 Research's concept for Chapter IV

In summary, this study addresses the research question about the patents before IPO positively signal the IPO performance across Japanese firms in diverse industries.

1.2.3. Does Patent Signaling Vary Contingently Under Technology Intensity? Evidence From High-tech and Low-tech IPO Firms in Japan

In chapter 4, we investigated whether Japanese companies across all the industries effectively utilize patents as signals to reduce information asymmetries between the company and investors, instilling confidence in investors regarding a firm's technological prowess and future prospects, thereby facilitating the acquisition of external financial capital at IPO. Nevertheless, the effectiveness of patent signaling is far from uniform across all industries, and it may be contingent upon the specific sector to which a company belongs, a factor that has garnered relatively little attention in prior research (Motohashi, 2008).

In this context, this chapter aims to delve into the intriguing dynamics of patent signaling within the context of IPO firms, distinguishing between high-tech and low-tech sectors. We argue that while it is widely acknowledged that information asymmetry associated with R&D and patent activity disclosure is more pronounced in high-tech industries than in low-tech sectors (Prędkiewicz et al., 2021), the nuances and implications of these differences for IPO performance have remained relatively uncharted territory.

High-tech and low-tech companies, despite sharing the common goal of innovation, exhibit fundamental disparities in their operations and financial characteristics (J. Kim et al., 2008). In the context of high-tech firms, the challenge of information asymmetry linked to their R&D and patent activities is particularly pronounced, surpassing that faced by their low-tech counterparts (Prędkiewicz et al., 2021). While previous research has addressed distinctions between high-tech and low-tech companies, their IPO performances have not received adequate attention. Yet, these differences encompass various aspects, such as motivation, underlying technology, and long-term performance (Carpenter et al., 2003; J. Kim et al., 2008; Matsuura et al., 2022), which may influence the intricate relationship between patents and IPO success.

High-tech firms often engage in complex innovation projects to bolster their technical competitiveness, with patent protection being a common outcome (Satta et al., 2016). The highly technical and intricate nature of patented technology, coupled with limited historical patent data, renders their patent portfolios less transparent to external observers. Furthermore, high-tech enterprises allocate substantial resources to innovation projects, often yielding little to no profit in their early stages (S. Gao & Hou, 2019). This unpredictability in profiting from innovation adds risk to financing such ventures. Additionally, high-tech companies typically possess substantial intangible assets in the form of patents and intellectual property, further complicating assessments. For high-tech projects, expert evaluation is often imperative, posing a challenge for many investors (Prędkiewicz et al., 2021). These factors collectively contribute to the high information asymmetry associated with advanced technology and innovative projects in high-tech firms, limiting the prospects for securing investment.

In contrast, low-tech firms, while possessing fewer patents, often harbor patents of substantial value, readily discernible through product development and operational activities (J. Kim et al., 2008). Consequently, they transmit clear and positive signals to prospective investors in the lead-up to an IPO. These firms adopt a more balanced resource allocation strategy, which is inherently less dependent on cutting-edge technological advancements. This simplicity in their business models and product offerings makes them more accessible to a broader range of investors, who may not possess the specialized knowledge required to assess the intricacies of high-tech ventures (Prędkiewicz et al., 2021)

This divergence between high-tech and low-tech IPOs raises us a critical question: are high-tech firms less successful than their low-tech counterparts in using patent signals to raise total capital during the IPO process? This question is vital because the characteristics of high-tech and low-tech firms are often ignored in prior studies on IPOs, as all IPOs are typically bundled together (J. Kim et al., 2008). Moreover, previous literature, while exploring the patent signaling phenomenon, has predominantly focused on high-tech firms in technology-intensive sectors, mainly within risk-tolerant markets like the United States and Europe. Remarkably absent from this discourse is an exploration of patent signaling's significance within Japan's more risk-averse landscape, particularly across a spectrum of industries encompassing both manufacturing and non-manufacturing sectors (Matsuura et al., 2022).

Current study specifically addresses following questions:

- Do patents before IPOs from Japanese low-tech firms have stronger signaling effect, therefore receiving more capital from investors at IPO?
- Do patents before IPOs from Japanese high-tech firms have stronger signaling effect, therefore receiving less capital from investors at IPO?
- Do patents before IPOs from Japanese high-tech firms have relatively weaker signaling effect apply for different industrial classification?

The conceptual framework of our study is demonstrated in **Figure 1.3**

Figure 1.3. Conceptual framework of study

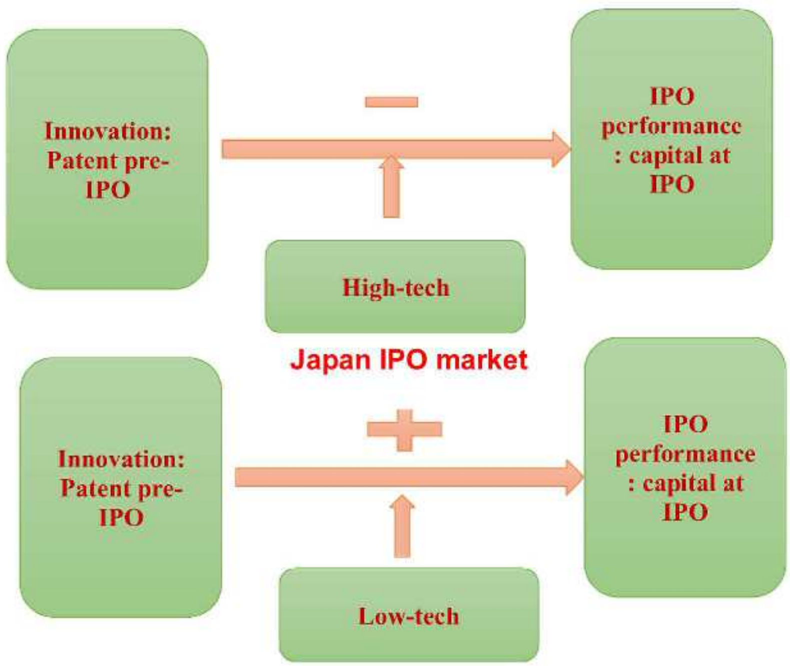


Figure 1.3 Research concept for Chapter V

1.3. Data collection and Methodology:

1.3.1. Research Methodology:

In these three studies, we mainly adopt empirical research methodology. At the theoretical level, the analysis paradigm of general economics is utilized to demonstrate the impact of firms' financial source on innovation output and the effect of innovation to the success of firm's IPO.

At the empirical level, we applied the method of descriptive statistic, correlation analysis for Preliminary Analysis. We use Poisson regression for the main analysis in Chapter 3 and Multiple Linear Regression for the main analysis in Chapter 4 and Chapter 5.

Our data are analyzed and managed by Microsoft Excel; STATA software; and Python.

1.3.2. Data collection:

The data from the stock market are mainly obtained from the Japanese Exchange Group (JPX)'s database.

The financial data in our research are collected from Refinitiv Nikkei; Needs-Financial Quest (FQ) and Thomson Reuter Eikon database.

The data on the patents are collected manually from the Jplatpat and Derwent Innovation Index Database.

We collect the information of industrial classification from OECD iLibrary and Thomson Reuter Eikon classification.

1.4. Key Contributions

Finance and innovation are integral components of a company's success, closely intertwined to shape its competitiveness and growth. Finance provides the necessary resources for investment in new products, services, and technologies, while innovation enables companies to stand out in the market and meet evolving customer demands. However, previous research has often segregated these areas, focusing on either the influence of innovation on financial performance or finance's impact on innovation. To address this gap, our research takes a comprehensive approach, examining how finance affects innovation and how innovation signals influence financial performance. This holistic exploration is essential for a deeper understanding of these complex dynamics. The key contributions that our study is expected to make to the current literature are presented below.

First, the majority of previous studies on innovation's relevance to IPO performance have focused on high-risk tolerance markets like the United States and European countries. Our study adds a unique dimension by concentrating on Japanese corporations. Japan's unique economic characteristics, including risk-averse markets and global competition, emphasize the pivotal role of innovation in sustaining economic growth. Our research highlights that even in risk-averse settings like Japan, patents effectively boost a firm's financial performance. Our study's distinctiveness lies in its comprehensive approach, investigating how finance influences innovation and how innovation's signals affect financial performance within Japanese corporations, offering a nuanced understanding of the finance-innovation interplay.

Second, our thesis confirms the Pecking Order Theory in small and young Japanese enterprises, highlighting their unique financial strategies. These firms prioritize self-generated financing, especially cash flows, to minimize risk, and turn to external sources like loans and shares only when internal funds are exhausted, often preferring debt over equity. This divergence from the strategies of larger corporations expands the literature. Businesses, particularly those in early stages, should prioritize self-generated financing for reduced risk and innovation support. Policymakers should acknowledge these unique behaviors and design policies promoting internal financing and facilitating access to debt financing, stimulating innovation and economic growth in these sectors.

Third, our research enriches the innovation-to-finance literature by exploring the pivotal role of patents as signals in the IPO, a critical milestone in a company's journey. We conclusively demonstrate that patents, as a proxy for innovation, serve as dependable indicators of IPO performance, resulting in more substantial capital proceeds from investors. These findings bolster existing research and expand the scope to encompass all industry sectors in the Japanese market, affirming patents as effective tools for reducing information asymmetry and gaining external financial support. This contribution bears practical implications on two fronts. For businesses, especially those eyeing an IPO, investment in innovative endeavors and the cultivation of a robust patent portfolio can substantially amplify IPO outcomes by attracting increased investor capital. Policymakers, on the other hand, should offer incentives for innovation and patenting to streamline external capital access for emerging companies, ultimately fostering economic growth, particularly in risk-averse markets.

Four, our research further contributes to the innovation-to-finance literature by dissecting the patent signaling effect across distinct technological domains, distinguishing between high-tech and low-tech enterprises. While prior studies often grouped all IPOs together or concentrated on specific industries like biotechnology, semiconductors, software, and the internet, our study adds fresh insights to the entrepreneurship and innovation landscape. We assert that patents exert a more substantial influence on IPO success for low-tech companies in comparison to their high-tech counterparts. This observation underscores the necessity for an in-depth exploration of the patent signaling mechanism in IPOs, especially for low-tech firms characterized by simpler innovation portfolios and tangible assets appealing to risk-averse investors. Our research yields practical implications for management and strategy, particularly for high-tech firms. It advises caution in relying solely on patents for IPO success due to the intricacies of their innovation projects. A prudent approach might involve selectively deploying patent signaling strategies to specialized investors, like institutional investors and investment banks, possessing in-depth technology expertise and higher risk tolerance. High-tech companies should also consider strategies for mitigating information asymmetry related to R&D and patent disclosure, including furnishing comprehensive project details to potential investors and exploring secondary offerings once they've solidified their market presence.

Finally, our thesis makes a valuable addition to the existing body of literature that employs patents as a metric for evaluating innovation performance. This contribution is significant because we delve into a nuanced analysis that discerns between the quantity and quality of patents. This distinction is essential as it highlights the multifaceted nature of patents, elucidating their distinct roles in offering early indicators of technological shifts and serving as tangible representations of innovative accomplishments. By focusing on both the quantity and quality aspects, our research provides a more comprehensive understanding of the intricate relationship between patents and innovation, shedding light on their specific contributions to the innovation landscape.

1.5. Structure of the thesis:

This thesis comprises of six chapters. In chapter 2, we introduced the literature review of current researches on the effect of finance to innovation performance and the signal effect of innovation to finance respectively. Chapter 3, we present paper one, in which we investigate the impact of financial sources on firm's innovation output based on the Japanese market. In Chapter 4, we discuss the relationship and influence between pre-IPO innovation and the firms' financial performance at IPO in Japan. In Chapter 5, we delve further into the relation between innovation and financial performance. Specifically, we explore the intricate relationship between patents and financial performance during the IPO stage, with a particular emphasis on understanding how this relationship can vary depending on the industry in which a company operates in. Chapter 6 concludes the thesis by summarizing the main findings reported in the three papers and discussing their implications, along with the study limitations and future research prospects.

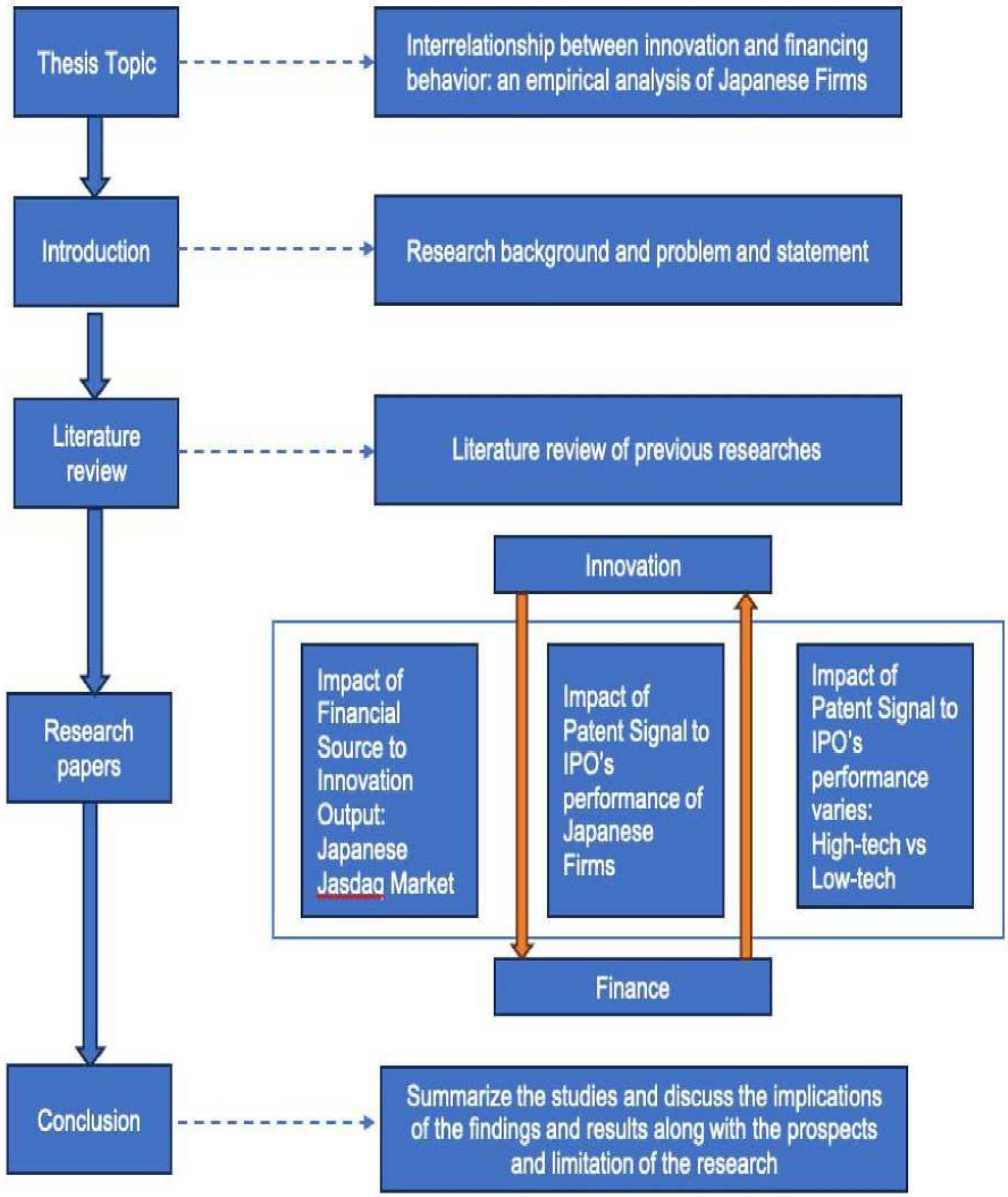


Figure 1.4 Structure of the thesis

CHAPTER II: LITERATURE REVIEW

2.1. Literature Review on the effect of Finance to Innovation

Theoretical underpinnings for the link between innovation and economic growth can be traced back to century-old work of Schumpeter (1934). Schumpeter argued that the financial system is important for contributing to innovation, which in turn positively influences economic growth. According to Schumpeter's theory, finance is a fundamental catalyst for innovation activity. His perspective underscores that financial resources and mechanisms are the lifeblood of innovation in an economy. Finance is crucial in several key ways:

- Firstly, innovation often requires significant investment in R&D, the creation of prototypes, and the exploration of novel ideas. These activities demand substantial financial backing. Without access to capital, businesses, whether they're startups or established firms, may lack the resources needed to bring their innovative concepts to fruition.
- Secondly, Schumpeter emphasizes the role of entrepreneurs in driving innovation. Entrepreneurs, as the engines of creative destruction, rely on financial resources to bring their visions to life. Finance enables them to experiment with new technologies, develop novel business models, and take calculated risks, all of which are vital components of innovation.
- Furthermore, financial markets and institutions provide a mechanism for allocating resources to the most promising and innovative ventures. Investors, whether individuals, venture capitalists, or other financial entities, play a crucial role in identifying and supporting innovative companies, which, in turn, fuels economic growth.

In essence, Schumpeter's theory of economic development provides a valuable framework for understanding the importance of finance to innovation activity. Finance is essential for entrepreneurs to develop and commercialize their new ideas, which is the key driver of economic growth. Starting with Schumpeter, there has been a growing number of empirical work on the relationship between a firm's financing and innovation assumes the common wisdom that the direction of causality goes from finance to innovation. The modern literature provide a wide range of perspectives on the relationship between firm financing and innovation, including theoretical models, empirical studies, and case studies. They cover a variety of topics, such as the role of different types of financing , such as external finance, banking sector growth, debt, equity, stock market development, financial structure in innovation across different countries and regions; the impact of financial constraints on innovation, and the relationship between financial innovation and innovation activity etc.

External finance has a complex and dynamic relationship with innovation. While it enables firms to access more capital and resources for innovation, it also imposes stricter disclosure requirements and may lead to myopic incentives that constrain innovation. (Le et al., 2019) delved into the interplay between financial development and innovation, categorizing financial development into bank-based and stock-market-based domains and exploring their impacts on innovation. Their investigation, encompassing a sample of 25 Asian countries from 2000 to 2015 and employing the Two-step Generalized Method of Moments, compellingly demonstrated that financial development that financial development, as measured by both banking sector growth and stock market development, significantly promotes innovation. The findings emphasize the positive impact of banking sector growth and stock market development on the number of patent applications across the sampled Asian countries.

In the context of emerging markets, (Kapidani & Luci, 2019) investigated the relationship between financial development indicators and innovation across 15 developing countries. Their comprehensive analysis encompassed data from 1996 to 2016. The study results highlight a positive association between financial development indicators and innovation within developing nations. More precisely, indicators such as the size of the banking sector, stock market capitalization, and financial structure demonstrate a substantial influence on innovation outcomes.

Also digging into external sources of finance (Čihák et al., 2021) investigate the correlation between financial structure and innovation. Their analysis of cross-country micro data spanning from 2009 to 2018 underscores that a firm's financial resources significantly influence both the decision to innovate and the extent of innovation. The empirical findings reveal that companies that secure funding through external channels exhibit higher innovation levels compared to those reliant on internal funding. Furthermore, harnessing external financial resources is linked with enhanced innovation prospects, particularly in more financially developed nations.

Continuing the exploration of external financial sources, with a specific focus on banking finance, the study conducted by (Chava et al., 2017) offers compelling evidence. It illustrates that banks discern the value of a firm's intellectual property, particularly in its patent portfolio, and consequently offer loans at more favorable terms. Furthermore, the research reveals that loan spreads are narrower when a borrower's patents hold higher value for the lender, which is discernible through factors like increased citations and broader applicability of the patents. This insight underlines the significant role of intellectual property in shaping lending practices and the cost of capital for firms.

Turning the focus to equity finance, a study by (Popov & Roosenboom, 2009), conducted in 2009, leveraged an extensive 18-country panel dataset spanning from 1991 to 2004. The research aimed to investigate the impact of private equity investments on innovation across European nations. Empirical analysis of the data yielded compelling results. It showcased that private equity investments exert a positive influence on innovation within European countries, a conclusion substantiated by employing Kortum and Lerner's empirical methodology. Specifically, the study unveiled that private equity financing constitutes a noteworthy share, contributing to 8% of aggregate industrial spending and an even more substantial 12% of industrial innovation. This finding underscores the pivotal role of private equity in driving innovation outcomes within the European context.

Sharing the same interest in the interplay between financial development and technological innovation cross-country, (Kassimatis & Spyrou, 2001) used a vast dataset encompassing 32 developed and emerging nations and employing a fixed effects identification strategy, the study delves into how the evolution of equity markets and credit markets influences technological innovation. The results indicate a pivotal role played by financial market development in shaping technological innovation across diverse industries and countries. Particularly, industries reliant on external finance and characterized by high-tech intensity demonstrate significantly elevated innovation levels in countries with well-established equity markets. This underscores the crucial relationship between financial market maturity and technological advancement in specific sectors and nations.

Presenting an alternative viewpoint, (Trinugroho et al., 2021) contend that the connection between finance and innovation is not always straightforward. Their research investigates whether financial development can elucidate the pace of innovation across 68 developed and developing countries from 1995 to 2018. Utilizing panel data and considering market institutions, the study unveils a nonlinear relationship between financial development and innovation. This suggests that the influence of financial markets on innovation is nuanced. Specifically, the developmental levels of credit and equity markets exert a positive impact on a country's innovation, but only up to a certain threshold. Beyond this threshold, further financial development ceases to significantly contribute to innovation. This underscores the complexity of the interplay between financial development and innovation, highlighting the need for a nuanced understanding of their relationship.

In partial alignment with findings by Trinugroho et al. (2021), (C.-B. Wang & Huang, 2021) arrived at their own conclusions. They determined that financial structure does not exert a significant influence on innovation in economies with lower levels of development. However, in more advanced economies, a market-based financial structure significantly fosters innovation within the industry. Their investigation into the impact of financial structure on innovation involved empirical analysis using manufacturing data from 59 countries or regions spanning the period from 1996 to 2015. These results emphasize the nuanced nature of the relationship between financial structure and innovation, shedding light on its dynamics across economies at different developmental stages.

The recent literature of financial resources has ignited a growing interest in understanding the impact of financial constraints on a firm's innovation capabilities. This heightened attention stems from the realization that these constraints can significantly hinder innovation, making it a top priority in microeconomic research. Innovation plays a pivotal role in driving economic growth, making it imperative to address the challenges posed by financial constraints to facilitate innovation within firms.

For instance, (Savignac*, 2007) conducted an extensive study using data from 1940 French manufacturing firms. Employing a recursive bivariate probit model, the research explored the influence of financial constraints on innovation. The findings clearly demonstrated that financial constraints have a substantial negative effect on a firm's likelihood of engaging in innovative activities. Moreover, the study highlighted that the likelihood of encountering financial constraints is influenced by a firm's pre-existing financing structure and economic performance.

Additionally, the work of (Vassilis & Frédérique, 2007) delves further into the relationship between financing constraints and innovation. Their research reveals that financing constraints exert a significant negative influence on a firm's innovative capabilities. Even after accounting for variables like R&D investment and innovation experience, firms with higher financing constraints are less likely to succeed in innovating. These findings underscore the notion that financial constraints indeed act as formidable barriers to innovation.

In contrast to the prevailing consensus that limited access to financing adversely affects innovation outcomes, (Almeida et al., 2013) introduce a compelling counterargument. Their viewpoint suggests that financial constraints could, counterintuitively, have a positive impact on innovation by enhancing the efficiency of innovative activities. They contend that financial constraints help alleviate free cash flow problems, which often lead firms to make unproductive R&D investments outside their core expertise. Instead, these constraints redirect the focus towards improving innovative efficiency, measured by patents. Notably, the positive effect of financial constraints on innovative efficiency is most pronounced in firms with high excess cash holdings, limited investment opportunities, and those operating in less competitive industries. The relationship between a firm's financing and innovation is complex and multifaceted. While financial constraints can undoubtedly hinder a firm's innovation capabilities, some argue that these constraints may also drive increased innovation efficiency. Thus, addressing financial constraints remains a crucial task, requiring a nuanced approach to promote innovation within firms, particularly given the pivotal role of innovation in driving economic growth.

The contemporary research on the interplay between firm financing and innovation offers diverse insights that shed light on the complex relationship. External finance presents a double-edged sword, providing access to essential resources for innovation while potentially imposing constraints that hinder innovation. Moreover, financial structure is found to be a significant determinant of innovation. Companies that harness external financial resources exhibit higher innovation levels, particularly in more financially developed nations. This reinforces the idea that access to external funds encourages innovation, underscoring the importance of balanced financial structures for innovative activities. Addressing financial constraints is also a critical aspect of fostering innovation. While financial constraints can undoubtedly hinder innovation, some studies propose that these constraints may paradoxically enhance innovation efficiency, particularly in firms with specific characteristics, such as high excess cash holdings, limited investment opportunities, and those operating in less competitive industries. In conclusion, the contemporary research underlines the complex and multifaceted nature of the relationship between firm financing and innovation. Ultimately, fostering innovation within firms requires a balanced approach, recognizing the diverse facets of the financing-innovation relationship.

The summary of literature review on the effect of Finance to Innovation is presented in the **Table 2.1.**

Table 2.1 Summary of Literature Review of Finance on Innovation

No	Paper	Authors	Sample	Industry Level/Country Level	Method Used	Result
1	The Relationship Between Financial Development and Innovation: Empirical Evidence from Selected Asian Country	(Le et al., 2019)	Panel Data set in 25 Asian Country from 2000-2015	Country level	Two Step Generalized Method of Moment (GMM)	The development of the banking sector and stock market in Asian countries increases the number of patent applications, indicating a positive relationship between financial development and innovation.
2	The Effect on Innovation from Financial Sector Development: Evidence from Developing Country	(Kapidani & Luci, 2019)	Panel Data includes 15 developing countries from 1996-2016	Country level	OLS Regression model	Higher crediting by banking sector positively affects patent application Other financial intermediaries have lower efficiency in boosting innovation
3	Financial Inclusion and Stability: Review of theoretical and empirical link	(Čihák et al., 2021)	Cross-country micro data spanning from 2009 to 2018	Country level	OLS regression model	Firm's financial resources significantly influence both the decision to innovate and the extent of innovation
4	Lending to Innovation	(Chava et al., 2017)	US Firm from 1989 to 2017	Firm level	Regression discontinuity design	- Banks provide cheaper loans to firms with intellectual property.

5	Does private equity investment spur innovation? Evidence from Europe	(Popov & Roosenboom, 2009)	18-country panel dataset from 1991 to 2004.	Country level	Griliches linear regression	- Patent value improvement leads to cheaper loan - Private equity investment accounts for 8% of aggregate industrial spending - Private equity accounts for 12% of industrial innovation
6	Stock and credit market expansion and economic development in emerging market: further evidence utilizing cointegration analysis	(Kassimatis & Spyrou, 2001)	32 developed and emerging nations	Country level	Multivariate time-series methodology	I ndustries reliant on external finance and characterized by high-tech intensity demonstrate significantly elevated innovation levels in countries with well-established equity markets
7	Effect of financial development on innovation: Roles of market institution	(Trinugroho et al., 2021)	68 developed and developing countries during 1995-2018	Country level	GMM regression	- Nonlinear effect in finance-innovation relationship - Market institutions enhance the relationship.
8	Econometric Analysis of the Impact of Financial Structure on Innovation Based	(C.-B. Wang & Huang, 2021)	Manufacturing industry data for 59 countries	Country level	Fixed Effects Panel Model	- Financial structure has no significant effect on innovation at lower levels of economic development. - Market-based financial structure significantly

	on the Fixed Effects Panel Model					promotes innovation at higher levels of economic development.
9	What method of financing for young innovative companies: Internal financing, bank loan, or venture capital?	(Savignac*, 2007)	Data from 1940 to 2007 French manufacturing firms	Firm level	Probit Regression model	Financial constraints have a substantial negative effect on a firm's likelihood of engaging in innovative activities.
10	Financing constraints and a firm's decision and ability to innovate: establishing direct and reverse effect	(Vassilis & Frédérique, 2007)	Data collected by Banque de France and European Commission	Country level	Simultaneous bivariate probit with mutual endogeneity	Financing constraints exert a significant negative influence on a firm's innovative capabilities.
11	Less is more: Financial Constraints and Innovative Efficiency	(Almeida et al., 2013)	Data of US firms from 1980 to 2004	Firm level	Panel Regressions	- Financial constraints positively impact innovative efficiency. - Financial constraints mitigate unproductive R&D investment.

2.2. Literature Review on the effect of Innovation to Finance

Much of the empirical work on the relationship between a firm's financing and innovation assumes the common wisdom that the direction of causality goes from finance to innovation. A large body of literature starting with Schumpeter argues that finance leads to innovation, because the services that the financial sector provides allow capital and resources to be allocated to the highest value manage financial aspects significantly influences firm's capacity to innovate and engage in technological advancements. This perspective highlights the pivotal role that finance plays in facilitating and driving innovation, shaping the research focus and informing the understanding of how financial aspects interact with and impact the innovative endeavors of companies.

Conversely, a large body of literature follows (Granger, 1969), who famously argues that where innovation leads, finance follows. The statement refers to an alternative viewpoint regarding the relationship between finance and innovation, one that challenges the traditional belief that finance is the primary driver of innovation. Instead, it suggests that innovation can precede financial activities and influence a firm's financial decisions, which then follow the path set by innovative activities. It suggests that when innovative projects create opportunities, firms may seek out specific financial resources to support these endeavors, and this demand can influence a firm's capital structure. This bidirectional relationship recognizes that innovation can have a feedback effect on financial decisions and structures, and it highlights the dynamic interplay between finance and innovation within a firm's strategic landscape.

In this section, we will present the literature review for the reverse causation hypothesis, that innovation causes financial performance at both the country and sectoral level. The summary of literature review of the effect innovation to finance is displayed in Table 2.2.

In the study conducted by (Hai & Li, 2019), an extensive investigation was undertaken to establish a positive correlation between innovation performance and financial performance. Their comprehensive analysis utilized a multi-source dataset, encompassing 142,975 firm-year observations from Chinese manufacturing firms over the period of 1999 to 2009. The empirical findings from their analysis unequivocally supported the notion that firms with stronger innovation performance tend to exhibit superior financial performance. Furthermore, the paper delved into the nuanced relationship between innovation and financial performance, specifically exploring how financial constraints may influence this connection. The results shed light on the fact that firms grappling with financial constraints can still reap benefits from innovation, albeit with potential moderating factors or the need for strategic management.

Shifting focus to the bio-pharmaceutical sector in (L. Zhang et al., 2019) conducted empirical research, honing in on the pivotal role of patent signals in influencing venture capital funding. Their study concentrated on the bio-pharmaceutical industry and revealed that legal signals, particularly those conveyed through publicly available invention patents, exert a substantial impact on venture capital decisions. In essence, this research aligns with prior literature, reaffirming the profound influence of patent signals on venture capital financing choices among Chinese venture capitalists.

Exploring innovation within the context of small and medium enterprises (SMEs), (Bigliardi, 2013) delves into its influence on the financial performance of SMEs operating in the food machinery industry. Her study draws from a survey involving 98 SMEs and employs regression-based analysis to investigate the correlation between innovation and financial performance. The results affirm that elevating the innovation quotient has a positive impact on financial performance, especially when the innovation is tailored to meet customer demands or create differentiation from competitors.

Focusing on the impact of innovation proxies, such as patents and trademarks, (H. Zhou et al., 2016) conducted a compelling study that yielded valuable insights. Their research illuminates the profound influence of patents and trademarks on venture capital financing, showcasing both direct and complementary effects. Notably, their findings reveal that startups filing at least one patent before seeking VC funding secured an impressive 51.7% more venture capital compared to those without patent filings. Moreover, startups engaging in trademark applications also experienced a substantial boost, with 39.7% higher VC funding compared to their counterparts without such filings.

Building upon these insights, (Czarnitzki et al., 2014) delved into the critical role of patents as signals to investors, especially Venture Capitalists. Their investigation focused on how firms' patenting activities impact the extent of financing constraints faced by established US firms in the realm of research and development (R&D). Their unwavering findings unequivocally demonstrate that patents play a pivotal role in mitigating financing constraints, particularly benefiting smaller firms marked by pronounced information asymmetries and limited collateral value.

In a similar vein, (Audretsch et al., 2012) proposed that nascent ventures strategically utilize patents to signal their capability in safeguarding intellectual property rights, while prototypes serve to demonstrate the feasibility of their innovative ideas to potential investors. Their empirical evidence, drawn from a unique dataset comprising 906 nascent high-tech ventures in the United States, strongly supports this proposition. It confirms that nascent ventures equipped with patents or patent applications and tangible prototypes of their innovations substantially enhance their likelihood of securing equity finance.

(Haeussler et al., 2014) sharing the same interest in venture capital exploring how the patenting process impact the ability of new ventures in the biotechnology sector to attract venture capital financing. The study uses a sample of British and German biotechnology companies seeking VC financing to test several hypotheses . The findings suggest that the filing of patent applications is positively related to VC financing, and the examination process at the patent office generates valuable technological and commercial information that influences the likelihood of VC financing for new ventures. Overall, the patenting process plays a crucial role in updating investors' expectations regarding the quality of new venture in biotechnology industry.

In contrast to previous research in this field, (de Oliveira et al., 2018) put forth the notion that innovation efforts do not directly translate into improved financial performance. According to their perspective, innovation efforts must first yield tangible innovation results or impacts before they can significantly contribute to a company's financial gains. The study draws on data from the Brazilian Institute of Geography and Statistics, encompassing an analysis of 5,025 firms. It employs exploratory factor analysis and structural equation modeling to scrutinize this relationship. The findings suggest that while innovation efforts may indeed generate impacts, these impacts do not inherently lead to an enhanced financial performance. This research seeks to contribute to the ongoing discussion regarding the firm-level implications of innovation in a large developing country. This is particularly pertinent due to the mixed empirical results found in the existing literature on this subject.

Financing at IPO is vital for a firm's growth and expansion, while the impact of innovation on IPO performance garners attention due to its influence on investor interest and valuation. This dynamic interaction between innovation and IPO performance has garnered significant research attention to shed light on how these factors shape a company's trajectory as it goes public. (Useche, 2014) addresses the value and nature of patents as signals of innovation in the IPO market for software firms in the US and Europe. It investigates whether patenting prior to an IPO impacts the perception of software firms' potential and the capital invested at the IPO stage. The findings reveal significant and positive correlations between pre-IPO patent applications and the IPO funds raised, underscoring the signaling power of patents. Moreover, the study highlights regional differences, showing that an additional pre-IPO patent application increases IPO proceeds by approximately 0.507% for US companies and 1.13% for European companies, indicating variations in patent signaling strength between these regions.

(Bessler & Bittelmeyer, 2008) continue contribute to the innovation effect of IPO performance by analyzing the relationship between innovation and performance for German firms that went public at the "Neuer Markt" from 1997 to 2002, specifically focusing on the impact of patents on underpricing and financial long-run performance measured by abnormal return. The empirical evidence suggests that patents are a reliable indicator for the success and performance of start-up technology firms that went public, with higher quality patents having more pronounced valuation effects. The study provided convincing evidence that innovation has a positive impact on the value and financial long-run performance of technology firms.

Overall, the collection of researches reinforces the idea that innovation plays a pivotal role in shaping a firm's financial performance, with patents often serving as a significant signal of innovation's value to investors, while also considering moderating factors like financial constraints and tangible innovation result

Table 2.2 Summary of Literature Review of Effect of Innovation on Finance Performance

No	Paper	Authors	Sample	Industry Level/Country Level	Method Used	Result
1	More innovation, more money? Innovation performance, financial constraints, and financial performance	(Hai & Li, 2019)	142,975 firm-year from Chinese manufacturing firms over the period of 1999 to 2009.	Firm level	statistical analysis	- Innovation performance positively affects financial performance - Financial constraints negatively affect innovation performance
2	How patent signals affect venture capital: the evidence of bio-pharmaceutical start-ups in China	(L. Zhang et al., 2019)	Panel Data includes 457 bio-pharmaceutical start-ups in China	Firm level	Multiple Linear Regression	- Patent signals have the greatest influence on venture capital funding levels. - Technological signals also have a significant impact.
3	The effect of innovation on financial performance: A research study involving SMEs	(Bigliardi, 2013)	Data from 98 SMEs in food machinery industry in Italia	Firm level	Survey method: five-point Likert-type scale	- Innovation increases financial performance in SMEs. - Innovations developed for customers and to differentiate from competitors have a

					positive impact on financial performance.
4	Patents, trademarks, and their complementarity in venture capital funding	(H. Zhou et al., 2016)	Data of 1726 uniquely identifiable start-ups	Country level	Clustered OLS regression	- Patents and trademarks have direct and complementary effects on venture capital financing. - Start-ups that apply for both patents and trademarks receive higher VC funding.
5	Patents as quality signals? The implications for financing constraints on R&D	(Czarnitzki et al., 2014)	4,309 unique firm-year observations in a broad range of industries	Country level	IV regression	- R&D investments are discouraged by imperfections in capital markets - Patents provide signals to external investors to mitigate financing constraints
6	Financial signaling by innovative nascent ventures: the relevance of patents and prototypes	(Audretsch et al., 2012)	Data on 906 nascent ventures in 2005	Firm level	Survey methos: sending email invitation and random sample of web visitors	- Ventures with patents and prototypes are more likely to obtain equity finance - Nascent ventures with patents or patent applications are more likely to obtain equity finance.

					And bivariate probit regression	
7	How patenting informs VC investors- the case of biotechnology	(Haeussler et al., 2014)	116 German and 74 British biotechnology company	Country level	Cox hazard regression	- Filing patent applications positively related to VC financing. - Patent examination process generates valuable information for VC financing.
8	Innovation and financial performance of company doing business in Brazil	(de Oliveira et al., 2018)	Data gathered by the Brazilian Institute of Geography and Statistics	Firm level	Kaiser-Meyer-Olkin statistic and Cronbach's alpha.	- Innovation efforts do not directly translate into financial performance. - Efforts in innovation possibly generate impacts, but do not necessarily imply better financial performance.
9	Are patents signals for the IPO market? An EU-US comparison for the software industry	(Useche, 2014)	Panel data from 2000 to 2009 of 234 software firm from US and 242 firm from EU	Country level	OLS Regression model	- Positive correlation between patent applications and IPO finance performance - Signaling power of patents differs between US and Europe
10	Patents and the performance of	(Bessler & Bittelmeyer, 2008)	Panel data of 258 Germany	Firm level	Cross sectional	- Patents are a reliable indicator for the success

technology firms: evidence from initial public offering in Germany	firm going public from 1997 to 2002	regression analysis	and performance of start-up technology firms that went public. - Valuation effects are more pronounced for higher quality patents.

CHAPTER III:

FINANCIAL SOURCES AND FIRM’S INNOVATION OUTPUT: ANALYSIS OF JASDAQ MARKET

3.1. Introduction

The ability to respond to rapid-paced business and environment change is essential for firms' competitive advantage and sustainability. A firm can adopt different strategies to persistently sustain its competitive advantage but none, over the long-term, is as significant as the capability to cultivate and sustain innovation (Parpaleix et al., 2019). The drivers of firms' innovation outputs have been explored widely, particularly in the fields of innovation and management, but much are still not known on the integration between financial sources and innovation outputs (Materia et al., 2015). How influential financial sources and structure are in producing innovation outputs? How significant external and internal financial sources and structure are in supporting innovation outputs? Are innovation outputs influenced by risk inherited in different types of financial sources and structure? Firms' access to financial sources is imperative in their survival. Lack of financial sources prevent firms from entirely pursuing innovation activities leading to lower innovation outputs and survival rate (J. He & Tian, 2018). Hence, answer to these questions are fundamental for optimal exploitations of firms' financial sources and structure.

A corporate financial ssource is a composition of the external financing source (debt and equity) a firm adopts to capitalize operations and investment (e.g., financing innovation). Early work of (Modigliani & Miller, 1958) suggests an arbitration between tax advantage on debts and bankruptcy costs (trade-off theory) for firms to decide optimum mixture of debt and equity. Firms, at a certain level of tolerance on bankruptcy costs rely more on debts to benefit from tax deduction. Firms use more equities when their shares are overvalued to sell the shares at premium. Regardless, trade-off theory prioritizes the external financing sources into a firm`s financial structure. The presence of agency cost derived from information asymmetry shifted firms preferred financing approach from external to internal sources.

Following Pecking Order Theory, managers adopt hierarchy between types of financing from internal or self-financing to external starting from low risk to risky debts to shares in financing investment and projects (Myers & Majluf, 1984). Free cash flows and retained earnings usually are the main internal sources, while, loans and the issuance of shares as external sources. One important conclusion of this theory is that the external sources are required only if the amount of internally-generated funds are exhausted. In that case, firms prefer debt financing assumed to be less risky and followed by equity as their last financing option (Bharath et al., 2009)

In practice, financial supports for innovation activites is argued to favor the spirit in pecking order theory as first, the process of producing innovation outputs is inherently uncertain. (Kerr & Nanda, 2015) stresses that uncertainty in innovation is crucially different from other risky activities. Not only the probabilities associated with innovation success are difficult to estimate, the forms of financial source for innovation outputs also vary. From managers' view, outputs of financing innovation are difficult to evaluate, particularly since often the only way to understand is to invest in it. Therefore, in a market dominated by asymmetric information, bankruptcy risks and agency conflict, preferring external sources for financing innovation are costly and risky (Bartoloni, 2013). Firms with high internally-supported sources are prone to produce more innovation outputs.

Second, the challenge of financing long term based-projects such as innovation is compounded by one-sided investment's objective. Firms may not fulfill the short term profit-goal of equity investors. Innovation by nature takes several years to actually realize outputs and financial returns. Next, loans from banks assist firms to finance innovation through the continuous supply of funds without disposing part of firms' ownership to outsiders (Spielkamp & Rammer, 2009; Zingales & Rajan, 2003). Therefore, due to the uncertainty, short-term returns realization and disposition of ownership issues, financing innovation by equity requires acute consideration.

After decades and considerable number of researches offered in understanding structure of a firm`s financing sources, recently the attention has shifted to an equally important issue, that is, how a firm's financial structure can influence its competitive strategies and sustainable development (through innovation outputs) (Chibani et al., 2019; Mignon, 2009) (Matsuno, 2018) postulated that innovation output is not a mere discovery or inventions, but a series of corporate activities that will create effective economic effects for business activities (to increase in sales, operating profit, productivity, current assets, fixed assets, total assets, net profits). Thus, the significance of financial sources on firms' innovation outputs should explain their sustainable development. Understanding how financial sources and its composition can explain firms' innovation outputs and sustainable development is not only crucial for firms, but also to policy implementation. It offers opinion on how to stimulate technological progress with sufficient innovation-friendly infrastructures one country should have to support firms' innovation outputs (Khan et al., 2018). This leads researchers into the area of innovation to a question as to which financial sources firms can engage in to enable them offering sustainable financial development through innovation outputs, given a specific financial structure.

In spite of the significance of innovation outputs to firms` financial performance and sustainable development, financing innovation activities are often challenging primarily because of the firms' financial constraints (Acharya & Xu, 2017). This postulation is particularly applicable to young and small firms as their lack of a record of accomplishment and physical collateral shuts the door to common financing sources, such as loans from banks and public equity. It results in the firms to impose substantial financial constraints on their investment scope, thus preventing them from fully pursuing innovation activities and producing outputs (J. He & Tian, 2018). From the perspective of listed firms, young and fast-growing firms in junior markets of a stock exchange are expected to stimulate innovation activities (Bos & Stam, 2014; Colombelli et al., 2014). However, the constraint in the financial sources usually experienced by these firms may stop the production of innovation outputs.

Following the markets' less stringent listing requirements than established stock exchanges; listed firms in junior stock markets are seen to account for a large proportion of young and fast-growing firms in countries, such as Japan and the United Kingdom (Granier et al. 2019). Firms listed in these markets tend to have the potential to grow through successful innovation activities and often have higher need for financing to invest in R&D (Cowling et al., 2020; Y.-K. Lee et al., 2015). To compensate for their lack of internal financing for R&D, many firms seek external financing (Mina et al., 2013). However, despite growth potential, young and innovative firms often face difficulties in acquiring external financing (Czarnitzki & Hottenrott, 2011). It is plausible that young and innovative firms tend to have high uncertainty of their business outcomes. Owing to this high risk, external suppliers of capital, such as banks and investors, are hesitant to provide funds to young and innovative firms. As such, these firms tend to have more reliance on their internally-supported sources, consistent to the spirit in Pecking Order Theory. Thus, managers` ability in determining an appropriate mixture of a firm`s financing sources (internal and/or external sources) given the constraint and how the financial sources explain firms' innovation outputs are essentially important. Therefore, the situation has become the aim of this study to provide answer.

The statistical and empirical specifications of this study take innovation outputs as dependent variable. The upside of using this specification is it allows this study to examine association between different type of financing sources and innovation outputs, simultaneously. Notifying that, this is in line to the objective of this study as it does not attempt to examine causal effect of different type of financing sources and structure as well as innovation outputs. Insomuch, the aim of this study is straightforward, that is whether there is evidence that innovation outputs are influenced by different type of financing sources and structure.

The main contribution of this study to the current body of literature stems from two aspects. First, the empirical evidence on the influence of financial sources and structure on innovation outputs have largely ignored the potential interrelation within financial sources of a firm. Past studies focused mostly on the influence of financial sources from the external financing aspect (debt versus equity). The inclusion of internal source (free cash flows) in the examination is pertinent to understand the influence of risk inherited in different types of financial sources to innovation outputs. Second, this study focuses on smaller and start-up firms perceived to have strong incentive to unceasingly engage in producing innovation outputs. In spite of the claim that large, established and multinational firms due to their strong financial supports usually dominate innovation (Ughetto, 2008); innovation in reality is dominated by smaller and start-up firms, such as firms in JASDAQ market, a junior market for public listed firms with certain sizes in Tokyo Stock Exchange (TSE). JASDAQ is a market characterized by the three concepts of (1) reliability, (2) innovativeness as well as (3) region and internationalization. JASDAQ is for growth firms with a certain size and business performance. Comparing JASDAQ market and other markets in TSE; Main market and Mothers, JASDAQ market requires smallest market capitalization to qualify private firms for listing in the TSE. Additionally, JASDAQ market allows listing of private firms without any consecutive years of conducting business (TSE, 2020), which denotes the eligibility of young and start-up firms to participate as publicly-owned entities in the TSE.

Junior stock market, such as JASDAQ accounts for large proportion of young and fast-growing firms. Considering potential complexity for young and start-up firms in acquiring and deciding appropriate financial sources and structure for financing innovation as well as the unique characteristics of firms in JASDAQ itself, a study on how financial sources and its composition can explain firms' innovation outputs that skewed its sample to this market is considered important. The use of firms in JASDAQ is also consistent to the spirit of Pecking Order Theory, given certain difficulties in the acquisition of financing sources due to the nature of firms in this junior market. The employment of firms publicly listed in the TSE as sample is also due to the global recognition of Japan as a dynamic innovation hub and a country that grows in a sound innovation environment. This can be referred to the high number of R&D activities and innovation outputs with high universal validity the country has produced.

The rest of this chapter is designed as follows. Section 2 reviews relevant literature. This is followed by Section 3 which describes methodology used in this study. Section 4 discusses the empirical results, while Section 5 presents conclusions drawn from the findings.

3.2. Hypothesis Development and Theoretical Framework

3.2.1. Patent as an Innovation Indicator

While innovation is considered the engine of economic growth, measuring innovation is not easy. Measuring innovation is subjective and difficult to offer an overall view in a continuous manner. R&D expenditure is frequently employed to proxy innovation or technological progress. However, expenditure is an input for R&D rather than an output of R&D, which is innovation. Another proxy is total factor productivity (TFP) which is influenced by factors other than innovation, and it has its own measurement problems, such as its procyclicality and difficulty in obtaining a good price index, particularly for goods with fast quality change or services (Nagaoka et al., 2010). As such, in this study, it resorts to patent-based data as the indicators for innovation output, similarly proposed in (Dang & Motohashi, 2015)

Various studies have attempted to evaluate patent-based data as indicator of technological change and innovation output (Afuah, 2014; Hall et al., 2005, 2009; J. He & Tian, 2018; Igami & Subrahmanyam, 2019; Katila, 2000; Kleinknecht et al., 2002). Each patent covers a wide information in terms of fields and types of inventors for the insensitive activity all around the world. Highly elaborated information on the innovation itself, the technological area to which it belongs, the inventor, the geographical location and the assignee is presented in any single patent (Hall et al., 2005). Moreover, innovation output measured by patent data may constrain the information asymmetry in view of the fact that patents are governed and protected by law, making the market more transparent. Patent also discloses all "prior art" of firms' innovation activities (Afuah, 2014). Patent encompasses the success of all (both observable and unobservable) innovation inputs (financial supports, talent allocation, distribution of effort to innovative projects and internal incentive schemes), especially non-monetary ones such as public acknowledgement (J. He & Tian, 2018), preferring patent as appropriate proxy for innovation outputs (Katila, 2000). Furthermore, patent enables one to analyse not only quantity of innovation's outputs, but also quality and fundamental attributes, estimated by citations, generality, originality, and their relevance to firms' core businesses. (Kleinknecht et al., 2002) highlighted the use of patent data as an (intermediate) output measure of innovation. Patent records offer the most comprehensive and detailed overview of technical knowledge over long time periods. (Hall et al., 2005) pointed out that patent is readily available, including on the Internet, contains considerable details and can be used to develop time series comparison.

In actual definition, patent has been the only indicator containing magnificent information on new technology and its information is screened systematically by considerable resources over a long- time frame. (Nagaoka et al., 2010) posited two decisive factors in increasingly using patents as innovation indicator. First, patent database has been developed and improved time after time by National Bureau of Economic Research (NBER), European Patent Office (EPO) and Japan Institute of Intellectual Property (IPP). Since other indicators are abstract, time-consuming and not statistic-friendly by their nature of size, patent data is a superior measurement for innovation. As a common practice, firms monitor the technological change and patenting activities of other firms using patent data and information generated by patent offices. Second, firms effortlessly access patent database and conduct sophisticated statistical analysis with the help of high quality technology and software. It has never been easier than ever to utilize patent data for evaluating technological innovation.

Recent evidence suggested that patents and their refinement are the prominent innovation predictors (Igami & Subrahmanyam, 2019). The researchers assessed the usefulness of patent database as an indicator of innovation using a direct measure of innovation in the hard disk industry. The finding on emerged patents are positively correlated with innovation in a statistically significant manner. In other words, patents are adjudged as a capable indicator for innovation and technological changes that the researchers wished to study which appears both advisable and feasible. (Kerr & Nanda, 2015) signified the volume of patenting and the patent citation in the recognition of a definitive approach to assessing innovation. Those patent database have been connected to the economic value and have raised the crucial insight on the effect of finance into innovation. As a result of numerous advantages to the use of patent data, this research designates patent-based data as a prominent indicator for technology change and innovation outcome.

By definition of patent, one type of the intellectual properties (IP), it is the granting of a right by patent and trademark office to an inventor. This grant provides the inventor exclusive rights to the patented product, design or process for a specific period as a return to a disclosure of the invention. A patent application is a request for the grant of a patent for an invention described in the patent specifications. Meanwhile, patent publication is the public release of an applied patent by the patent and trademark office. Patent citation is defined as a patent document cited by the applicant or third party as it denotes the extent of firms' technological advancement and economical value; as high citation scores indicate novelty of innovation outputs (Hall et al., 2009)In this study, different categories of patent: application, publication and citation innovation outputs are estimated their significance as proxy to innovation output.

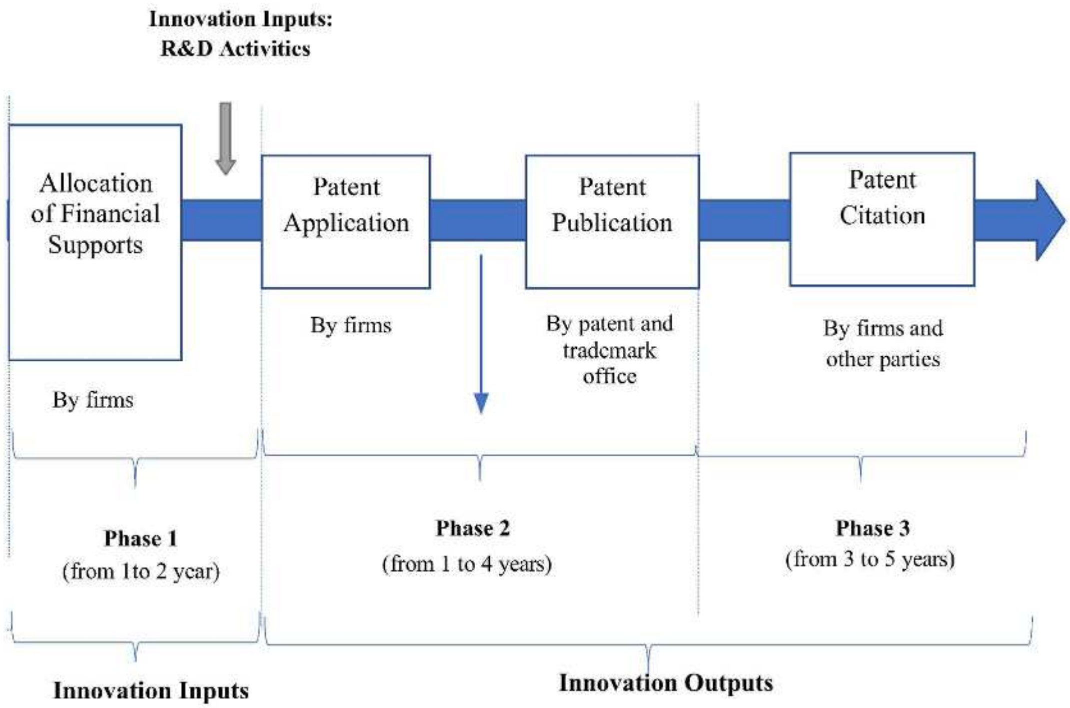
3.2.2. Innovation Output:

In this study, innovation outputs are estimated using patent-based measure, namely: patent application, publication and citation. A patent application is a request for the grant of a patent for an invention described in the patent specifications. Meanwhile, patent publication is the public release of an applied patent by the patent and trademark office.

However, patent-based data such as patent application and publication is the type of intermediate output measure. In other words, patent application and patent publication reflect technical knowledge, but it is not necessarily measuring the commercialization of innovation. To overcome this fuzziness, in this study it examines another preferable indicator - patent citation as improved measure of technological performance. Patent citation conveys the previous patents and other extensive literature on science and technology linkage by subject, geographic location and source of investment in the prior art and differentiate from the past patent (Hall et al., 2005).

The reason for patent citation is not only an indicator of technological activity, but also commercialized innovation output being two-fold. First, a profit-seeking firm decides to refer to the extensive technology exposed in a prior art and then further conduct an innovation. The theory was that not only technical breakthroughs, but also market value is more often used as a baseline with which to compare later improvements on that basic technology. Hence, in likelihood the cited patent is a sign of economic value that the company aims for the costly innovation activities. Second, a patent citation is active over a period of time, hence if a patent is still cited time after time, it demonstrates the credibility of both superior technology and commercial worth.

Truncation is another important factor that this research would investigate, mainly the difference in terms of truncation among three innovation output proxies: patent application, patent publication and patent citation in the robustness check. As suggested by (Dass et al., 2017), there is a time lag and an uncertain delay in periods between when a firm applies for a patent and when the patent is granted or published (if, successful). The lag between patent application and patent publication can be from one to three years, thus suggesting the start of the truncation issue on the patent data. While the lag between the application date and publication date is possibly up to a maximum of three years (Dass et al., 2017); the application date of a patent is usually closer in time to the firms' innovation activity. In this sense, this study should expect that a patent can be applied by firms in one or two years after the



allocation of financing to the firms' innovation activities (R&D activities) is made.

Figure 0.1 Truncation in Patent-based Data

With regard to patent citation, defined as a patent document cited by the applicant or third party, the truncation issue is even stronger as citations of a patent which usually will take years to be accumulated or considered matured, after a patent has been granted, for one to understand the patent's impact and performance. As posited in Marku (2018), the higher the impact of a patented invention on subsequent inventions, the higher will be the number of citations a patent receives. The truncation of patent-based data, from the scope of this study, is illustrated in **Figure 3.1.**

3.2.3. Financial Sources, Structure and Innovation Outputs:

(Savignac, 2006) and (Gorodnichenko & Schnitzer, 2013) postulate that innovation outputs are negatively influenced by the constraint in financial sources. The studies shown that inadequacy of the internal financing source, proxied by cash-flows and past profitability, is the main factor to the underinvestment in innovation activities and it reduces the likelihood of firms producing outputs. One of the ways to understand this finding is to observe reasons of asymmetric information related to the intangible nature of human and knowledge assets used in the early phase of innovation activities involving search and prototype development. Firms aiming to innovate usually rely on less risky source that is internal financing source. Firms shift to relatively costly financing sources (debt and equity) for later innovation phase (production and marketing of the new products) only when internal sources are exhausted. As such, firms trying to complete innovation activities with outputs likely to face financial constraint, especially if loan application to banks are rationed out by terms and conditions. Thus, firms are less capable to produce quantity and quality of desired outputs, given the financial constraint. (Hall, 2002) and (Savignac, 2006) show the effect of financial constraint on innovation outputs differ across industries, firms size, age, market share and technology push.

The significance of internal financial source to innovation outputs is also implied in the findings of (Ughetto, 2008) for 1000 Italians manufacturing firms that cash flow is the main financing source, especially for small firms. While Italian firms obtained a significant share of financing from debt, the finding showed that firms used virtually no debt to produce innovated products. Financial risk might be the reason to the finding. As posited by (Kerr & Nanda, 2015), uncertainty in the duration and form of innovation outputs, as it is difficult to estimate at the beginning whether and when financing innovation will pay off and what economic value it has. Hence, this has made firms not to finance innovation by riskier sources (debts) as it exposes firms to certain level of bankruptcy risk and collateral requirements. In such cases, firms opt to the safest mode of financing (internal sources) to eliminate the costs. Therefore, firms with more cash and other necessary resources in hand will produce more innovation outputs (Spielkamp & Rammer, 2009). From the context of this study, it hypothesizes that firms will have more patents application, publication and citation in cases where amount of the internally-generated funds is high, as developed in ***Hypothesis 1.***

Hypothesis 1: *Patents application, publication and citation are positively influenced by firms' internally-generated source of financing (cash flow).*

Relying on internal financing source to support innovation outputs is not ultimate as firms, even though they are public, may choose debt financing when they require additional funds to innovate. As found in (Spielkamp & Rammer, 2009), using German public firms as sample, debt financing is main substitution to cash flows. The rationale is: firstly, loans from banks assist firms to finance innovation through the continuous supply of funds (Zingales & Rajan, 2003), without giving up parts of firms' ownership to outsiders. Next, innovation takes several years to actually realize outputs and financial returns and is less able to fulfil short term profit-goal of equity investors. Firms are prone to debts for financing innovation in attempt to reduce the investment objective misalignment. Hence, given the inferiority of equity financing as opposed to debt financing in some aspects, this study hypothesizes that patents application, publication and citation are positively influenced by the proportion of firms' debt to equity, as shown in ***Hypothesis 2.***

Hypothesis 2: *Patents application, publication and citation are positively influenced by firms' debt to equity ratio.*

The development of ***Hypothesis 1*** and ***Hypothesis 2*** leads this study to also examine the proposition built in Pecking Order Theory that firms will adopt hierarchy between types of financing from internal or self-financing to external financing, starting from lower risk to risky debts followed by the issuance of shares on their efforts in financing innovation. This is to provide answer to the question: Is innovation influenced by risk inherited in different types of firms' financial source and structure? As this study employs sample of firms from JASDAQ market, having rather smaller market capitalizations (or, are smaller in size) and lesser operational history and experience, it is convenient to postulate that those firms are superior to financial constraint but averse to risk. The superiority to the constraint in the internally-generated financing and aversion on risk, alongside the overall risk on innovation should lead the firms to prioritize their financing from cash flow to debts and later, equity as their last option, as developed in ***Hypothesis 3a*** and ***Hypothesis 3a.***

Hypothesis 3a: *Patents application, publication and citation are influenced by hierarchy in financial sources between internal financing and external starting from self- generated sources to external sources.*

Hypothesis 3b*: Patents application, publication and citation are influenced by hierarchy in external financial sources from debts to equity.*

3.3. Methodology and Research Design

3.3.1. Sample Size and Procedures

The population of this study consisted of publicly traded firms listed in the JASDAQ market of TSE. This study used a final sample of 113 firms in the manufacturing industry. With the rapid technological change in recent decades, modified products (product innovation) or alterations in the ways that they are produced (process innovation) are often witnessed in the manufacturing industry. That is, the manufacturing industry is constantly undergoing phases of change, from the emergence of new technologies to Industry 4.0. This rapid-changed revolution posits that manufacturing firms are urged to continuously innovate in order to remain competitive to the market. Thus, the use of this industry as sample is rather relevant. Data used in this study spanned a period of 13 years from 2003 to 2015, consisting of yearly data on patent-based elements (application, publication and citation) and firms' specific data (innovation inputs, size, age, pay- out distribution, public listing experience, investors sentiment and sector dummy). The closing year (2015) in the sample period of this study has been chosen to enable this study to have sufficient observation (5 years) of citation received for a particular patent starting from the year of publication to its assumed maturity. This study used the data gathered from the Japanese Exchange Group (JPX)'s website, Refinitiv Nikkei and Needs-Financial Quest (FQ) databases and Derwent Innovation Index Database.

For the estimation method, this study opted for count model, which leveraged on Poisson regression. Count model is used when y takes integer values that represent the number of events that occur — examples of count data include the number of patents filed by a company, which this suits the data used in this study. Poisson regression assumption imposes constraints that are often violated which is the equality of the (conditional) mean and variance. If the mean-variance equality does not hold, the model is arguably mis-specified. To reduce the issue, this study conducted maximum likelihood estimation as its count estimated method. These quasi-maximum likelihood (QML) estimators are robust in the sense that they produce consistent estimates of the parameters of a correctly specified conditional mean, even if the distribution is incorrectly specified.

3.3.2. Definition and Measures:

- ***Dependent Variable: Innovation Output:***

Data on patent were collected from Derwent Innovation Database. This database enabled the retrieval of trusted patent data from more than 40 patent offices including those applied and granted in the Japan Patent Office. The following equations denote the specification of each patent data used in this study.

$$\text{Application}_i = \sum_{j=1}^{n} \text{application count}_{ij} \quad (1)$$

Where:

Application_i is the count of patents applied in a particular year of the i^{th} firm

$$\text{Publication} = \sum_{j=1}^{n} \text{publication count}_{ij} \quad (2)$$

Where:

Publication_i is the count of patents published in a particular year of the i^{th} firm

$$\text{Citation}_i = \sum_{j=1}^{n} \text{citation count}_{ij} \quad (3)$$

Where:

Citation_i is the count of patents cited in a particular year of the i^{th} firm

To address the issue of truncation in patent data, this study integrated data on patent application of a firm from one year to four years after financial sources (cash flow, debts and equity) were reported in firms' financial reports, for statistical examination. Meanwhile, this study used data on patent publication of a firm from two years to five years after the reporting of the financial data or from one year to four years' after a patent has been applied. In addition, this study employed data on patent citation received by a firm within five years to seven years from the reporting of the financial data or three years to five years after patents of a firm in a particular year have been published. All the time lags and delays identified not only enabled this study to address the truncation issue on patent data, but also allowed this study to investigate the influence of the different type of firm's financing sources on innovation outputs using different sets of time on patent data individually in separate statistical models.

- ***Independent Variable: Financial Structure and Sources:***

The different type of financing sources, treated as the main independent variable in this study, are assessed from the two aspects that are internal financing source and external financing source. The external financing source is the proportion of debt and equity of a firm estimated on the yearly basis. A higher debt to equity ratio, from the unfavorable aspect, can be an indicative of the potential of bankruptcy cost a firm is bearing. However, it can also denote the importance of debt financing as opposed to equity financing to the firm. **Equation 4** presents the estimation of debt to equity ratio.

$$EXTERNALFIN_i = \frac{Debt}{Equityij} \quad (4)$$

Where:

$Debt_i$	=	Yearly amount of total debts of the i^{th} firm.
$Equity_i$	=	Yearly amount of total shareholders' equity of the i^{th} firm.

The internal financing source is captured using firms' cash flows on the yearly basis (Gorodnichenko & Schnitzer, 2013; Savignac, 2006). The amount of cash flow, besides an indicative of the direct internal potential of a firm's financing, also has been one of the most important indicators in testing the firms' external financial constraint as an adequate rate of operating cash flow denotes favorable conditions of a firm for attracting funds from external sources (Spielkamp and Rammer, 2009). Also, despite the argument that a firm's operating cash flow is a modest measure to firms' internal financing source, it actually denotes other important features. The operating cash flow is influenced by both profitability of a firm and the level of corporate taxes. In such instances, firms that receive tax subsidies and produce high net profits will experience increment in their operating cash flow indicating the ability of the firms in exploiting for tax deduction benefits and making a sound profitability margin (Wan & Zhu, 2011)As such, operating cash flow can be of a suitable proxy for capturing current reality of a firm's internal financing strength. The specification of internal financing source is as presented in the **Equation 5**.

$$INTERNALFIN_i = \frac{Operating\ Cash\ FLowi}{Total\ Assetij}$$

Where:

Operating Cash Flow$_i$	=	Yearly amount of cash flows of the i^{th} firm.
Total Assets$_i$	=	Yearly amount of net Assets of the i^{th} firm.

- ***Control Variables:***

In studying the influence of different financing sources on firms' innovation output, this study controlled for a set of other independent variables that have included firms' characteristics and market sentiment. The inclusion of these variables was mainly to ensure that the influence of financial structure and sources on firms' innovation outputs were not due to the omission of other relevant explanatory variables. The summary of all other independent variables and their theoretical arguments used by this study can be found in ***Table 3.1.***

Table 3.1 Summary of Control Variables and Expected Signs

No.	Control Variables	Proxy (Measurement)	Theoretical Arguments	Exp. Sign	Empirical Evidence
1.	R&D Intensity *(R&D EXP)*	R&D Allocation (R&D expenditure divided by total sales)	R&D activity facilitates the assimilation, improvement and exploitation of the existing knowledge. It increases the ability of a firm to absorb new technologies emerging on the market for firm competitive advantage (Hadhri et al., 2016) Public firms engage more in R&D activities will generate more innovation outputs (measured by patents) (Acharya & Xu, 2017)	**+ve**	**+ve:** (Archibugi, 1992) (Bozeman et al., 2007) (Hadhri et al., 2016)
2.	Profit Distribution *(PAYOUT)*	Dividend Payout (dividends paid out to shareholders divided by net profits)	The increased in internal cash holding (used as an intermediary to R&D intensity) is accomplished by a lower dividend policy. That is, a policy of low dividend payout practiced by a firm increases the firm internal funds, innovation activity (measured by R&D intensity) and firm value, consequently. - (N. Lee & Lee, 2019)	**-ve**	**-ve:** (N. Lee & Lee, 2019)
3.	Investor Optimism *(OPTIMISM)*	Market Value (share price multiplied by the number of ordinary shares)	Market overvaluation, through a direct reflection to investor optimism, is positively associated to firms' innovation. Market overvaluation generates social value by increasing innovative outputs and by encouraging firms to engage in highly inventive innovation (measured by originality, generality, and novelty of the innovative investments). Stronger effect of market overvaluation on innovative projects is found in firms with greater growth (Dong et al., 2017)	**+ve**	**+ve:** (Dong et al., 2017)

4.	Firm Size *(SIZE)*	Firm Size (natural log of total net assets a firm)	Firm size represents the access to innovation activity, the ability to diversify risk and the potential to benefit from scale economies. Larger firms usually invest more on innovation activity due to their ability in diversifying risks. For manufacturing firms, large firms also obtain a larger total benefits from process innovations (through lower production costs) (Hadhri et al., 2016) On the other hand, smaller firms which represents greater specialization possibilities and better communication, tend to continuously introduce new products, develop new processes, make changes in the organizational structure and explore new markets. (Avermaete et al., 2003)	**+ve**	**+ve:** (Galende & de la Fuente, 2003) (Spielkamp & Rammer, 2009) (Zemplinerová & Hromádková, 2012) (Hadhri et al., 2016) (Wojnicka-Sycz et al., 2018) **-ve:** (Avermaete et al., 2003)
5.	Organizational Resources *(OSOURCE)*	Age (number of years of establishment prior to listing of a firm)	Age represents the experience and knowledge accumulated throughout a firm's history and is related to a better management of communication and of necessary creativity to innovate as well as a more effective capacity for absorption. Age is used to measure the experience and resources of firms.(Galende & de la Fuente, 2003). Older firms are viewed to reap out the advantage of having necessary inputs for innovative projects and that produce more innovation outputs.	**+ve**	**+ve:** (Galende & de la Fuente, 2003) **-ve:** (Zemplinerová & Hromádková, 2012)
6.	Going Public *(PUBLIC)*	Listing Experience (number year of listing prior to the examination year)	Going public changes firms' strategies in pursuing innovation. Supporting for an agency explanation: out of career concerns, managers are averse to innovative projects, which are long term and highly risky in nature.	**-ve**	**-ve:** He and Tian (2017)

			Since public firms face more severe agency conflict than private companies, managers are more likely to divert resources away from innovation activity. In specific, going public may impose short-term pressure on managers to focus more on quarterly profits rather than on long-term earnings potential, leading to the "managerial myopia" problem (Stein, 1988)		
7.	Industry *(INDUSTRY)*	Industry dummy equals one if a firm is categorized as chemical firm and zero, otherwise	Industry dummy controls for inter-industry differences in factors, such as technological and economic opportunity. Higher levels of innovative activity are more likely to be observed in concentrated industries – Schumpeter (1942)	**+ve**	**+ve:** (Spielkamp & Rammer, 2009)

Notes: +ve (-ve) indicates an expectation and empirical evidence on the positive (negative) relationship.

3.3.3. Estimated Equations:

$$Application_i = \beta0 + \beta1EXTERNALFINi + \beta2INTERNALFINi + \beta3R\&DEXPi + \beta4PAYOUT + \beta5OPTIMISMi + \beta6SIZEi + \beta7OUSOURCEi + \beta8PUBLICi + \beta9INDUSTRYi + ei \quad (6)$$

$$Publication_i = \beta0 + \beta1EXTERNALFINi + \beta2INTERNALFINi + \beta3R\&DEXPi + \beta4PAYOUT + \beta5OPTIMISMi + \beta6SIZEi + \beta7OUSOURCEi + \beta8PUBLICi + \beta9INDUSTRYi + ei \quad (7)$$

$$Citation_i = \beta0 + \beta1EXTERNALFINi + \beta2INTERNALFINi + \beta3R\&DEXPi + \beta4PAYOUT + \beta5OPTIMISMi + \beta6SIZEi + \beta7OUSOURCEi + \beta8PUBLICi + \beta9INDUSTRYi + ei \quad (8)$$

Where:

- Application is the count of patent applied in a particular year
- Publication is the count of patent published in a particular year
- Citation is the count of patent cited in particular year(s)
- $\beta 0$ is the constant term
- $\beta 1$~ $\beta 9$ are the estimate coefficients
- i is the ith firm
- EXTERNALFIN is the Debt to Equity Ratio
- INTERNALFIN is Cash Flow
- R&D EXP is the R&D Expenditure to Sales Ratio
- PAYOUT is the Dividend Distribution
- OPTIMISM is the Investors Optimism
- SIZE is the Firm Size
- OSOURCE is the Organization Resources
- INDUSTRY is the Dummy Chemical Products Sectors
- e is the Error term

3.4. Result and Discussion

3.4.1. Preliminary Analysis

The aim of this study is to quantify the influence of financial sources and structure on firms' innovation outputs. This study uses Poisson regression models for data analyses as patent application, publication and citation; employed to proxy innovation outputs, are observed count data, the nonnegative integers (0, 1, 2, 3) and assumed to have Poisson distribution. **Table 3.2** presents the distribution of sample firms employed in this study (Panel A and the descriptive statistics for patent data (Panel B). The sample from each sector is rather representative of its population with a total of 80.71 percent. In general, innovation outputs of the sample firms do portray some noteworthy diversities. As reported in Panel B, firms during the observation period (from 2003 to 2015), on average, have applied and published not more than 6 patents, yearly, although some firms have no patent applied and published in any year, while some others applied for 67 patents and published for 99 patents in a single year. The published patents are also cited, on average, five times regardless of whether the citations were accumulated within three years (4.78), four years (4.92) or five years (4.98) after publication of the patents. Some firms reported to have their patents cited as much as 88 times, while some other firms reported only zero number of citations for their patents published within the next three, four and five years. In contrast to patent application and publication which can denote number of innovation outputs, patent citation can signify the quality of innovation outputs as a patent of high quality, usually being cited more frequently, ceteris paribus (Lee et al., 2007). Thus, firms that reported high number of citations from their patents visibly have published relatively high economical value (Hall et al., 2009) and level of originality (Kang & Lee, 2017) on their innovation outputs.

The correlation coefficients are examined prior to the examination of the regression analyses. The independent variables should have a low correlation with other explanatory variables to avoid multi-collinearity problems which reduce the explanatory power of the independent variables. The matrix of independent variables presented in **Table 3.3** suggests little collinearity.

Table 3.2 Sample Distribution and Descriptive Statistics (Dependent Variables)

Sample Distribution and Descriptive Statistics (Dependent Variables)

Panel A: Distribution of Firms in Manufacturing Industry

Sectors	**Construction**	**Electrical Appliances**	**Transportation Equipment**	**Chemical Products**	**Metal Products**	**Total**
Population	32	46	14	29	19	140
Sample	27	37	13	22	14	113
Percentage	84.75	80.43	92.86	75.86	73.68	80.71

Panel B: Descriptive Statistics of Patent Counts

Patent Counts

	Patent Application				**Patent Publication**				**Patent Citation**		
Year Lag	1	2	3	4	1	2	3	4	3	4	5
Mean	5.36	5.08	4.92	4.81	5.99	5.64	5.33	5.11	4.78	4.92	4.98
Median	2.00	2.00	1.00	1.00	2.00	2.00	2.00	2.00	1.00	1.00	1.00
Maximum	67	67	67	61	99	73	73	73	85	88	88
Minimum	0	0	0	0	0	0	0	0	0	0	0
Std. Dev.	9.17	8.89	8.82	8.64	10.39	9.47	9.07	8.87	9.50	10.00	10.31

Notes: Year lag in patent application is calculated based on the duration between the year that information on financial sources (cash flow, debt and equity) are reported in firms' financial statement and the year that patent(s) of inventive projects are applied. Year lag in patent publication is calculated based on the duration between the year that patent(s) of the inventive projects are applied and the year that the patents are published. Meanwhile, year lag in patent citation is calculated based on the duration between the year that the patent(s) are published and the duration of which citation of the patents are accumulated after publication of the patent.

Table 3.3: Descriptive Statistics and Correlations (Independent Variables)

Notes: 1. EXTERNALFIN = Debt to Equity Ratio (%), 2. INTERNALFIN = Cash Flow (Dollar, 000), 3. R&D EXP = R&D Expenditure to Sales Ratio (%), 4. PAYOUT = Dividend Distribution (%), 5. OPTIMISM =Investors Optimism, 6. SIZE = Firm Size

	Sample Observations (N= 1469)									
	Mean	**Std. Dev.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
EXTERNALFIN	1.21	1.13	1.00							
INTERNALFIN	1257039	2419695	-0.13	1.00						
R&D EXP	0.03	0.04	-0.19	-0.02	1.00					
PAYOUT	2.04	1.65	-0.16	0.04	-0.04	1.00				
OPTIMISM	8752.32	17889.19	-0.19	0.30	0.07	-0.15	1.00			
SIZE	19712157	23603596	0.04	0.21	-0.06	0.04	0.46	1.00		
OSOURCE	53.95	20.16	-0.10	-0.02	-0.13	0.08	-0.04	0.11	1.00	
PUBLIC	12.3	5.03	-0.13	0.00	-0.05	0.06	-0.03	0.15	0.41	1.00
INDUSTRY	-	-	-0.00	0.09	-0.04	0.01	0.07	0.02	0.06	0.00

(Dollar,000), 7. OSOURCE = Organizational Resources (Years), 8. PUBLIC = Going Public (Years) and INDUSTRY = Dummy Chemical Products Sector.

The mean value for INTERNALFIN is higher than the mean value of EXTERNALFIN due to the different units of estimation. INTERNALFIN is measured by cash flow of the company in Dollar (JPY). Meanwhile, EXTERNALFIN is measured by debt-to-equity ratio. The huge deviation is expected and provides only minimal impact in the estimation (if any) because of the data transformation into natural logarithm when regressing the model in the later analysis stage. Huge deviation data have been minimized or standardized. As for the standard deviation, the standard deviation of INTERNALFIN is higher when comparing to EXTERNALFIN, indicating large dispersion of data for INTERNALFIN variable. There are firms having very low INTERNALFIN and firms with very high of INTERNALFIN which makes the dispersion to be greater, hence high value of standard deviation. Besides, all variables reported only raw data in Table 3 to demonstrate their actual characteristics. The data will be transformed before entering into regression analysis to minimize the estimation error.

All correlations among independent variables are low. The two highest coefficients are between OPTIMISM and SIZE (0.46) and between PUBLIC and OSOURCE (0.41), implying no significant multi-collinearity problems found among the independent variables of this study. Thus, reliable results from independent influence of all independent variables on innovation outputs can be obtained from the regression analyses.

The detailed of the Descriptive Statistic result is presented in **Appendix 1**

3.4.2. Main Analyses and Discussion

The results on the tests of the hypotheses postulated in this study are presented in Panel A, Panel B and Panel C of **Table 3.4** present results on the influence of the different financing sources (INTERNALFIN and EXTERNALFIN) on innovation outputs, separating into the different proxies, namely patent application, patent publication and patent citation, subsequently. On this note, the examination on the influence of the different financing sources on innovation outputs is done with the inclusion of the controlling effect of other variables, which the reporting of and the discussion on the results are made later in **Table 3.6** for specific emphasis.

The detailed of Main Analysis results are presented in **Appendix 2.**

Briefly, all hypothesized propositions built in this study are supported with significant effects. ***Hypothesis 1*** expects that innovation outputs are positively influenced by firms' internally- generated source of financing (cash flow). As reported in ***Table 3.4*** (from all panels), INTERNALFIN, abbreviates the internal source of financing which is significantly and positively associated to innovation outputs, regardless of proxies to innovation outputs and years lag. The explanatory power of firms' internal financing source (referred to z-statistics reported in the parentheses) on all proxies of innovation outputs do portray certain varieties which INTERNALFIN is found to positively influence patent application, patent publication and patent citation most strongly; when four years lag (Panel A and Panel B) and three years lag

(Panel C) counts of the proxies are used in the specifications. Regardless, the positive and significant association between firms' internal financing source and innovation outputs (at confidence levels of 99 percent) indicates that firms having more cash in hand produced more volume and quality of innovation outputs.

The results, provided in this study, support the findings revealed in (Gorodnichenko & Schnitzer, 2013), (Savignac, 2006) as well as (Ughetto, 2008). The proposition of this study from one aspect indicates the lowest financial risk denoted by the internal financing source, alongside future uncertainty related to the outcomes and risks on innovation; is difficult to assess at the early phase of the innovation activity whether and when it will pay off. Therefore, these conditions have led firms to opt for the safest mode for financing innovation.

From another aspect, the lower ability of firms, due to the inadequate rate of operating cash flow as essential precondition to acquire additional financial sources outside the firm; has resulted in firms to have lower incentive to engage in innovation activity, hence limiting their innovation outputs. This result is practically suitable for manufacturing firms leveraging on the complex connection between everyday financial functions such as inventory management, accounts payable and accounts receivable and cash flow adequacy. The incapability of firms to comprehend the connection, alongside the external issues of the unreliable customer demand forecasts and industry-wide, will usually expose manufacturing firms to the unexpected demand on their working capital, cash flow inflexibility and internal financial constraint. Therefore, without a strong support from the external financing sources, the engagement of firms to new chain of innovation activities will be less probable.

Table 3.4 also reveals that EXTERNALFIN has an equal importance as firms financing source. Regardless of proxies to innovation outputs and years lag, debt to equity ratio are found to positively and significantly relate to innovation outputs, as expected in Hypothesis 2: Innovation outputs are positively influenced by firms' debt to equity ratio. The positive association denotes that firms are inclined to choose debts to complement the self-generated funds (cash flow) for funding innovation. The higher the amount of debt in firms' financial structure, the higher is firms' innovation outputs. The results support the proposition of this study that suggested debt as a less sensitive financing mode to information asymmetry and agency conflict. The need for firms to disclose their confidential information and business secrets to outside investors when issuing for equity have caused hesitation for firms to use equity as their main external financing source for innovation.

In addition, the potential mis-matching issue on the investment objectives between firms and equity investors, as well as the short-term investors' pressure also justifies the firms' heavy and significant reliance on debt financing as opposed to equity financing in producing innovation outputs as reported in all panels of **Table 3.4**. In addition, a stable rate of cash flow as a safe-guard cushion to guarantee an easy access to debt makes firms to have less difficulty to fund their innovation via debts rather than using equity. Regardless, it is worth stating that despite similar confidence levels (referred to the asterisks) on the influence of EXTERNALFIN to firms' innovation outputs, their explanatory power is not as high as those

INTERNALFIN (referred to the z-statistics values presented in parentheses). Hereby, INTERNALFIN portrays a consistent superiority, as opposed to EXTERNALFIN, as a main driver to firms' innovation outputs. One important implication that can be drawn from this finding is that, both types of financing sources are complemented, but the preference of firms is to the internal financing source, probably based on the financing risks.

The results addressed on Hypothesis 1 and Hypothesis 2 seem to straightforwardly link to the subsequent Hypothesis 3: Innovation outputs are influenced by hierarchy in financial sources between internal financing and external starting from self-generated source to debts followed by equity. The positive and significant influence of both types of financing sources show their importance in producing outputs on firms' innovation activity. Leveraging on the values of z- statistics and the RSS value of INTERNALFIN and EXTERNALFIN in Panel A, Panel B and Panel C of **Table 3.4 and Appendix 2**, however, indicate that firms' innovation activity, while outputs are predominantly financed by self- financing means (cash flow). Meanwhile, the positive and significant association between debt to equity ratio and innovation outputs implies the preference of firms to debt financing in supplementing cash flow. As such, it is safe to initially conclude that firms used as sample of this study adopt hierarchy in financial sources between internal financing and external financing. In this situation, the priority is given to the safest financing mode to less risky and followed by relatively risky mode of financing.

As this study employs a sample of firms from JASDAQ market which is smaller in size, they have lesser operational history and are risk averse. Hence, it is rather appropriate to accept that the firms' financing decision should mainly be based on the risk of each financial source. This finding, besides supporting Hypothesis 3, also provides support to the proposition in Pecking Order Theory related to the risk inherited in different types of financial sources. Specifically, firms prefer internally-generated financing that is less risky, prior to debt financing that will only be used at the riskiest mode, equity financing as their last financing option.

Table 3.4. Poisson Regression Results (Debt to Equity and Cash Flow)

Panel A: Dependent Variable = Patent Application				
	Model 1	Model 2	Model 3	**Model 4**
Year Lag (From Allocation of Financial Sources)	1 Year Lag	2 Years Lag	3 Years Lag	4 Years Lag
INTERNALFIN	0.042 (12.783)***	0.053 (15.524)***	0.054(15.133)***	0.066 (16.717)***
EXTERNALFIN	0.103 (8.459)***	0.117 (9.503)***	0.105 (8.234)***	0.139 (10.931)***
Pseudo R^2	0.286	0.296	0.289	0.279
LLR p-value	0.000	0.000	0.000	0.000
Panel B: Dependent Variable = Patent Publication				
	Model 1	Model 2	Model 3	**Model 4**
Year Lag (From Patent Application)	1 Year Lag	2 Years Lag	3 Years Lag	4 Years Lag
INTERNALFIN	0.037 (11.816)***	0.045 (13.654)***	0.048(14.269)***	0.055 (15.629)***
EXTERNALFIN	0.115 (10.082)***	0.105 (8.850)***	0.112(9.288)***	0.106 (8.683)***
Pseudo R^2	0.269	0.279	0.281	0.277
LLR p-value	0.000	0.000	0.000	0.000

Panel C: Dependent Variable = Patent Citation			
	Model 1	Model 2	Model 3
Year Lag (From Patent Publication)	Within 3 Years	Within 4 Years	Within 5 Years
INTERNALFIN	0.042 (10.533)***	0.046 (10.618)***	0.054 (11.348)***
EXTERNALFIN	0.048 (3.149)***	0.055 (3.435)***	0.118 (7.703)***
Pseudo R^2	0.291	0.304	0.316
LLR p-value	0.000	0.000	0.000

Note: The reported values are coefficient estimates and z-statistics (reported in parentheses).

Table 3.5. Poisson Regression Results on The Interaction between Financial Source (Debt to Equity and Cash Flow) an R&D Intensity (R&D to Sales Ratio)

	Panel A: Dependent Variable = Patent Application			
	Model 1	Model 2	Model 3	Model 4
Year Lag (From Allocation of Financial Sources)	1 Year Lag	2 Years Lag	3 Years Lag	4 Years Lag
*INTERNALFIN*R& DEXP*	0.086(1.633)***	0.044 (0.832)***	-0.055(-1.153)	0.011 (0.198)***
*EXTERNALFIN*R& DEXP*	0.583 (2.483)***	0.608 (2.612)***	0.398 (1.680)***	0.035 (0.142)***
Pseudo R^2	0.287	0.296	0.289	0.278
LLR p-value	0.000	0.000	0.000	0.000
	Panel B: Dependent Variable = Patent Publication			
	Model 1	Model 2	Model 3	Model 4
Year Lag (From Patent Application)	1 Year Lag	2 Years Lag	3 Years Lag	4 Years Lag
*INTERNALFIN*R& DEXP*	0.075 (1.499)	0.0004 (0.008)***	0.061(1.176)	0.082 (1.521)
*EXTERNALFIN*R& DEXP*	0.765 (3.362)***	0.712 (3.127)***	0.506 (2.152)***	0.794(3.400)***
Pseudo R^2	0.269	0.279	0.281	0.278
LLR p-value	0.000	0.000	0.000	0.000

Panel C: Dependent Variable = Patent Citation			
	Model 1	Model 2	Model 3
Year Lag (From Patent Publication)	Within 3 Years	Within 4 Years	Within 5 Years
*INTERNALFIN*R&D EXP*	-0.203 (-4.117)***	-0.026 (-0.397)	0.195(2.147)***
*EXTERNALFIN*R&D EXP*	0.684 (2.572)***	0.849 (2.925)***	0.751 (2.470)**
Pseudo R^2	0.292	0.304	0.316
LLR p-value	0.000	0.000	0.000

Notes: The reported values are coefficient estimates and z-statistics (reported in parentheses).

The explanation on the significant and positive association between firms' financing sources and innovation outputs, thus far, is made with assumptions that innovation outputs are affected individually by the allocation of firms' financial sources to innovation activity. In most cases, however, the strong financing supports are interacted by the intensive R&D activity as the latter usually indicates the level of efforts devoted to produce innovative product and process as well as firms' response to the market's demand and improved technology. It can be posited that an effective interaction between financing sources and R&D intensity should support firms in producing more quantity and quality of their innovation outputs as both are viewed as a syndicated element to innovation performance.

Henceforth, the issue on how R&D intensity can moderate the influence of financial sources on innovation outputs should be of prime interest. R&D intensity, acknowledged as one of the most widely used measures of innovation inputs, is defined as the percentage of a firm's R&D expenditure to its sales. Panel A and Panel B of **Table 3.5** show that the interaction between internal financing source and R&D intensity (INTERNALFIN*R&D EXP) has a more significant influence on patent application and patent publication as opposed to the individual influence of INTERNALFIN as shown earlier in **Table 3.4.** Similarly, the interaction between external financing source and R&D intensity (EXTERNALFIN*R&D EXP) has a more significant influence on patent application and patent publication as opposed to the individual influence of EXTERNALFIN

Meanwhile, the interactions (INTERNALFIN* R&D EXP) influence quality of innovation outputs or patent citation less significantly as revealed in Panel C. In constract, the interactions (EXTERNALFIN* R&D EXP) is more significant than the effect of EXTERNALFIN to patent citation. This finding indicates that the interaction between of firms' external financing source (EXTERNALFIN) and dedicated focus on R&D can help firms to better match the patented products and increase market expectation through the arrival of inventive products that have never been produced before. It is often accepted that the significant investment of financial source on R&D activity comes with significant outcomes, which in the context of this study, are the quality of the patented outputs measured by its citation counts.

Seven other firms' characteristics are deduced from related literature to control for the influence of financing sources and structure on innovation outputs. The summary of the regression results on the influence of the firms' characteristics is presented in **Table 3.6**. All relationships are found to be significant with six of the characteristics, in terms of their sign of relationship, correspond with those expected by this study (**Table 3.1**). Specifically, similar to interacting it to financing sources, R&D intensity (R&D EXP) represents an internal strength to firms as more engagement of firms to R&D activities will assist them to generate more and better innovation outputs. R&D EXP is positively significant at 0.01 implying that the ability of a firm to absorb new technologies emerging on the market, which helps it to produce better innovative outputs, seemed to be confirmed.

Table 3.6. Summary of Poisson Regression Results on The Influence of Other Independent Variables on Innovation Outputs

Dependent Variables	Model 1 Patent Application	Model 2 Patent Publication	Model 3 Patent Citation		Significance (Confidence Level, %)	Confirmed Sign of Relationship and Significance
	Sign of Relationship					
	Actual	Actual	Actual	Expected		
R&DEXP	+	+	+	+	99%	Yes
PAYOUT	+	+	+	+	99%	No
OPTIMISM	+	+	+	+	99%	Yes
SIZE	+	+	+	+	99%	Yes
OSOURCE	+	+	+	+	95%	Yes
PUBLIC	-	-	-	-	99%	Yes
INDUSTRY	+	+	+	+	99%	Yes

Notes: Poisson regression results on the influence of the firms' characteristics on all proxies of innovation outputs presented in this table is consistently arranged according to the year's lag reported in Table 4. As significance level and sign of relationship of each of the firms' characteristic are found to be consistent across panels and years lags, the results are summarized as one.

Dividend distribution (PAYOUT), the second control variable, indicative of the level of firms' internal funds is also significant at 0.01. The positive sign of relationship between PAYOUT and innovation outputs (for all proxies) implies that firms' innovation outputs are higher when they pay their shareholders higher rate of dividend, which these results being not able to confirm the expectation of this study, while also offering a challenge to that found in Lee and Lee (2019). Higher rate of dividends probably provides a solid demonstration of the firms' ability in creating enough profits and sends a signal about firms' financial strength.

The adequate rate of profits a firm has created gives it more flexibilities to distribute the portion to shareholders, while maintaining certain level of cash flow to be used for firms' other operational purposes. Instead of lowering the rate of firms' internal funds, distribution of dividend denotes the internal financing strength of firms that an effective exploitation of the financial strength to firms' innovation activity is highly possible.

Another significant variable at 0.01 is investor's optimism (OPTIMISM), indicative of market overvaluation. The positive relationship, which indicates the response of firms to market overvaluation by engaging in more innovative activities, riskier and creative forms of innovation and later helping firms in producing higher and better innovative outputs, seem to be corroborated. Producing similar significant at 0.01, SIZE which is representative of the firms' accessibility to innovation activity, ability to diversify risk and potential to gain from scale economies, also confirms its expected positive association to all proxies of innovation outputs. The sign of relationship verifies that larger firms usually invest more on innovation activity due to their accessibility to all necessary resources at hand for innovation activity and ability in diversifying risks which results into higher volume and quality of innovation outputs.

Organizational resources (OSOURCE), with a positive relationship and significant at 0.05, represent the experience and knowledge accumulated throughout a firm's history and are related to a better communication management of communication and of necessary creativity to innovate and a more effective capacity for absorption. Age is used to measure the experience and resources of firms. The suggestion that older firms are at a better position to reap out the advantage of having necessary inputs for innovative projects and support for producing more innovation outputs, seem to be verified.

Going Public (PUBLIC), another variable significant at 0.01 is representative of the experience of firms in years as publicly-traded entities. The negative relationship seems to confirm the proposition that going public changes firms' strategies in pursuing innovation. Since public firms face more severe agency conflict than private companies, managers are more likely to divert resources away from innovation activity, in corresponds to their years as public firms. Going public may impose short-term pressure on managers to focus more on quarterly profits rather than on long-term earnings potential (innovation activity). Therefore, the longer the firms' listing experience is, the lower their motivation is to engage in innovation activity.

The last controlling variable, industry (INDUSTRY), is significant at 0.01. Using a dummy variable that equals to one for firms listed in the chemical sector; and vice versa, INDUSTRY produces a positive association to innovation outputs, denoting the importance of innovation to the sector. The superiority of innovation activity to this sector is in connection to the need in creating and satisfying increasingly sophisticated, demanding and environmentally-conscious consumers for chemical necessities and products.

3.5. Summary

This study explores the impact of financial sources, structure, and factors on firms' innovation outputs using Pecking Order Theory. It focuses on the drivers of firms' final innovative results, examining seven firms' characteristics such as R&D intensity, profit distribution, investor optimism, firm size, organizational resources, public listing experience, and sector dummy. A sample of 113 manufacturing firms listed on the TSE is used to analyze how firms' innovation outputs are explained by different types of financing sources. The findings are significant due to the diversity of patent-based data and the different aspects of financing sources used. It contributes to the growing literature on patent measurement, as patent documents provide early signals of technological change. The study indicates that firms depending on internal financing have a more significant effect on innovation outputs than external financing. It suggests that firms should prioritize generating higher cash flow as a primary means in gearing innovation outputs. Innovation outputs have a positive long-term effect on firms' share value, and focusing on increasing and maintaining cash flow can help public firms sustain longer in the stock market. Additionally, the research highlights the connection between innovation outputs and long-term shareholder value, making innovation-focused firms attractive to investors and contributing to a country's welfare by meeting changing consumer preferences.

CHAPTER IV:

IMPACT OF PATENT SIGNAL ON FIRM'S PERFORMANCE AT IPO: AN EMPIRICAL ANALYSIS OF JAPANESE FIRMS

4.1. Introduction

In today's global business landscape, the journey from entrepreneurial inception to sustainable growth is punctuated by a pivotal moment: IPO. Prior to producing consistent sales and profits from their goods or services, a company must obtain a sufficient amount of capital (Acharya & Xu, 2017). As a result, firms issue an IPO following an innovative breakthrough in order to raise capital. This transformative event marks a significant milestone for companies of various industries as they seek to secure the necessary capital for expansion, product development, and market penetration (Pástor et al., 2009; Solow, 1957).

The IPO marketplace is a dynamic arena where companies must not only distinguish themselves but also quell investor uncertainties surrounding valuation and future prospects. The allure of going public, however, is often juxtaposed with an intricate challenge—navigating the treacherous waters of information asymmetry between firms and potential investors(T. Wang et al., 2019). Unlike listed companies, private firms often lack reliable information such as about firms' specialized science and technology, operation records, cash-flow report. This hinders the abilities of investors to properly value the company before going public (Nagata & Hachiya, 2007; T. Wang et al., 2019). This may create an information asymmetry problem, which, in turn, results in difficulty predicting the long-term potential of an IPO company due to inaccurate valuation.

In order to make up for this information gap and address the challenge of information asymmetry, businesses provide signals of excellence to persuade outsiders of the firm's quality and potential. Investors are more willing to allocate resources when they have a favorable perception of the company. A variety of firm measures have been used as signals in the IPO market over the years. For instance, investment bankers (Daily et al., 2005; P. He, 2007; Jain & Kini, 1999) and business partners (LiPuma, 2012; Peng et al., 2021; Stuart et al., 1999) can serve as valuable signals for outside investors. Companies also signal the reputation of underwriters (Dong et al., 2011; Jelic et al., 2001; Su & Bangassa, 2011), CEO (Certo et al., 2007; Yang et al., 2011) and the size and qualifications of the top management team (M. C. Higgins & Gulati, 2006) during the IPO process to improve IPO success by reducing information asymmetry. Throughout history, these signals have functioned as prominent indicators, providing valuable guidance to investors navigating the complex realm of ambiguity.

Among these various signals, patents have emerged as a particularly intriguing and valuable source of information for investors. According to (Czarnitzki & Lopes-Bento, 2014), patents can serve as a reliable signal to reduce information asymmetry because patent details are verifiable by others, easily observable, and costly to maintain. A substantial body of research has explored the link between patents and firm growth, recognizing that patents signal a firm's potential to external investors, thereby enabling entrepreneurs to secure the financial capital necessary for innovation. While previous research primarily focused on patent signaling in venture capital-backed firms and startups in specific business sectors like semiconductors, software, and biotechnology (Ahlers et al., 2015; Baum & Silverman, 2004; Conti et al., 2013; MacMillan et al., 1985; Mann & Sager, 2007), there has been a relative paucity of attention in the literature regarding whether patents continue to act as a signal for companies in different industry sectors when pursuing IPOs.

Furthermore, earlier research predominantly focused on the United States (US) and European (EU) markets, where investors often exhibit a higher tolerance for risk. Surprisingly, as far as we are aware, no study has ventured into investigating the significance of patent signals to IPO proceeds in the more risk-averse Japanese market (Taplin, 2005). Therefore, our research objectives are clear: we aim to broaden the scope of our inquiry, encompassing all Japanese IPO businesses across diverse industry sectors. In doing so, we seek to reaffirm whether patents continue to serve as a useful signal, aiding companies in acquiring the financial capital they require to thrive in this unique market landscape. Our research is poised to shed light on the role of patents in mitigating information asymmetry and enhancing the success of IPOs in a market characterized by its distinct risk aversion and investment climate.

The implications of this study extend beyond the realm of academic inquiry; they hold profound significance for businesses navigating the complexities of raising capital through IPOs and policymakers shaping the regulatory landscape of financial markets. By dissecting the dynamics of patent signaling in the Japanese IPO market, we endeavor to contribute valuable insights that can inform both corporate strategies and policy implementations, ultimately fostering innovation and economic growth in this pivotal sector. In the following sections, we embark on this exploratory journey, seeking to unravel the intricate interplay between patent signals and firm performance in the Japanese IPO landscape.

4.2. Hypothesis Development and Theoretical Framework:

4.2.1. IPO, Information Asymmetry, and Quality Signal:

An IPO represents a pivotal event in the financial journey of a corporation, marked by its transition from a privately-held entity to a publicly-traded company. This transformation holds immense significance in the realm of corporate finance for several compelling reasons. First and foremost, an IPO provides a means for a company to access the capital markets and raise substantial funds. This infusion of capital can be instrumental in fueling growth, funding research and development endeavors, reducing debt burdens, and supporting working capital needs. It empowers the company to embark on ambitious expansion strategies and innovation initiatives, which, in turn, can bolster its competitive position and financial performance. Capital gained from IPO can be channeled into a variety of strategic initiatives, including expanding operations, investing in research and development, and reducing debt burdens. In essence, it provides the financial resources necessary to support the company's growth and innovation endeavors.

Additionally, an IPO provides a medium for increased prominence and trustworthiness. The act of becoming a publicly traded corporation often confers a heightened perception of credibility and reliability to the organization from the perspectives of its customers, suppliers, and investors. This enhanced reputation can pave the way for more favorable financial relationships, including improved financing terms and strategic partnerships. Moreover, the liquidity event provided by an IPO allows early investors, founders, and employees to monetize their stakes, potentially incentivizing their continued commitment to the firm's long-term success.

However, the path to an IPO is challenging, and one significant hurdle is the presence of information asymmetry. In the lead-up to the IPO, a company often possesses detailed knowledge about its operations, financial health, and growth prospects that is not readily available to external stakeholders, including potential investors. This information gap can create uncertainty and complexity in the valuation of the company. It is difficult for investors to understand the specialized technologies and cutting-edge knowledge of the firms. Besides, given that the majority of companies lack steady operations, earnings, and liquidity, it is challenging for external investors to determine their real value.

Consequently, investors depend on a company's quality signals, such as the company's strategies and decisions, the specific characteristics of the firm, or behaviors that might indicate its future potential (Bergh et al., 2014; B. D. Cohen & Dean, 2005; Connelly et al., 2011). IPO companies with stronger innovation skills are better able to respond to shifts in market demand, use resources inside the company wisely, and create new scientific and technological advancements. The signaling theory, first put forth by (Spence, 1973), suggests that IPO firms may affect investors' perceptions by delivering reliable signals that have an impact on their degree of trust and anxiety. Due to the fact that when partners have a positive view of a company, they are often more willing to share resources with that firm, (Lange et al., 2001) argued that companies use signals of a firm's excellence to convince third parties of its potential. Researchers have identified a number of indicators that act as pre-IPO signals for the firms, such as third-party affiliations like venture capital-backed companies (Gompers, 1996; Kirkulak, 2008; Ragozzino & Blevins, 2016).

(Gompers, 1996) concluded that young venture capital firms take companies pubic earlier than older VC firms in order to establish a reputation and successfully raise capital for new funds and found that companies backed by young VC firms are younger and more underpriced at their IPO than those of established VC firms. (Liao et al., 2014) investigated the effects of VC investments on corporate governance and financial stability of IPO-firms in the emerging markets and found that VC-backed firms have less agency problems related to excess control than non-VC-backed ones at the time of IPO, and venture capitalists are likely to encounter financial difficulty than non-VC-backed firms. Examining in the he effect of VC prestige on the post-issue survivability of IPOs and how VC characteristics influence the effect, (Chou et al., 2013)examined the effect of VC prestige on the post-issue survivability of IPOs and how VC characteristics influence the effect, finding that IPOs backed by prestigious VCs are less likely to delist for performance failure and have longer listing duration relative to those without VC backing.

Investment bankers (Daily et al., 2005; P. He, 2007; Jain & Kini, 1999) and business partners, (LiPuma, 2012; Peng et al., 2021; Stuart et al., 1999) which can be useful signals for outside investors. (Jain & Kini, 1999) find evidence of demand for investment banker monitoring in the IPO market and suggests that lead bank reputation is positively associated with post-issue performance. (Tong & Ahmad, 2015) examine the extent of the investment banks reputation, both high and low, affect the performance of the initial public offers (IPOs) on the Malaysian Main Board, Second Board and the MESDAQ market. The authors conclude that Reputation of investment banks affects IPO performance, in specific, High reputation banks have positive impact on Second Board IPOs, while low reputation banks have negative impact on MESDAQ IPOs.

Product development is also considered a quality indicator in various studies (Audretsch et al., 2012; Deeds et al., 1997; L. Guo, 2010). For instance, when it comes to addressing health issues, conducting experimental trials in clinical settings plays a crucial role in creating effective and safe solutions. Therefore, a biotechnology startup's clinical research reflects its capacity to test and enhance its products and services (Deeds et al., 1997; Hoang & Rothaermel, 2010). Notably, the U.S. Food and Drug Administration (FDA) provides extensive information about drug development on its official website (U.S. FDA, 2016), and this information is also emphasized in the IPO prospectuses of biotechnology startups. Given that clinical studies can be expensive (Hoang & Rothaermel, 2010), they are challenging for lower-quality ventures to replicate.

Companies also signal their reputation using underwriters (Dong et al., 2011; Jelic et al., 2001; Su & Bangassa, 2011), CEO background (Certo et al., 2007; Yang et al., 2011), founder reputation (Jain & Tabak, 2008; Wasserman, 2006) and the size and qualifications of the top management team (M. C. Higgins & Gulati, 2006) during the IPO process to improve IPO success by reducing information asymmetry.

(Hu et al., 2021) investigated the effects of underwriter reputation on initial public offering (IPO) underpricing in the Chinese Growth Enterprise Market. The insight shows that Underwriter reputation serves as a signal in IPOs, reducing underpricing by minimizing time gap, selecting high-quality firms, and reducing information asymmetry. (N.-Y. Kim & Hwang, 2018) empirically examined whether underwriter reputation is associated with the level of accounting conservatism of IPO firms in South Korea and found that an underwriter with a good reputation indicates an IPO firm with higher accounting conservatism.

Exploring the effect of CEO reputation on IPO performance, (Y. Zhang & Wiersema, 2009) proposed that attributes of the CEO send important signals to the investment community as to the credibility of theCEO certification and thus the quality of the firm's financial statements, which impact the stock market reaction to the CEO certification. Sharing the same interest in the field, the study of (T. Wang et al., 2019) found that signals of venture officers, including CEO background, play a stronger role than signals of technology development in enabling technology ventures to raise capital in their IPOs from data on 268 IPOs of biotechnology ventures in the United State. Entrepreneurs hold distinctive insights into their business's past, achievements, setbacks, capabilities, vulnerabilities, possibilities, and challenges (Jain & Tabak, 2008). This knowledge bestows them with a competitive edge in terms of information and decision-making abilities (Wasserman, 2006). Likewise, (N. Gao & Jain, 2011) discovered that companies with CEOs who are also founders tend to attain greater long-term returns compared to those helmed by CEOs who are not the founders. A discussion of the relationship between organizational legitimacy and the top management team (TMT) of a firm is offered. (M. C. Higgins & Gulati, 2006) prove that TMT members with prominent upstream, horizontal, and downstream affiliations are likely to attract high numbers of quality institutional investors that invest in young IPO firms.

(M. J. Higgins et al., 2011) and (Pisano, 2006) observed that the nature of the signal evolves over time, and investors may delay investment decisions until enterprises reveal more visible outcomes. In this sense, revealing information about company's innovations and competencies via patents may assist companies in attracting investors, therefore minimizing issues with asymmetric knowledge. As tangible results of the innovation process, patents serve as reliable indicators of how well a company's innovative efforts and technical prowess have worked (Griliches, 1998). Patents may convey to external investors a company's potential by indicating future outcomes with commercial worth (Hagedoorn, 2003). Moreover, patents are expensive to acquire and difficult to imitate, and they offer a selection process that enables observers to differentiate between various attributes (Long, 2002)(Hsu & Ziedonis, 2013). Also, because patent filings are publicly accessible, outside investors can use the information in them to the determine the worth of the firm's investment (Levitas & McFadyen, 2009). Thus, patents are regarded as sufficient indicators of a company's innovation capabilities for these compelling reasons.

4.2.2. Patent practices in the IPO context

Innovation is undeniably a cornerstone of a company's adaptability and competitiveness in a dynamic business landscape. Firms that foster innovation are not only better equipped to respond to evolving consumer demands but also adept at optimizing internal resources and consistently generating novel ideas and solutions. Nevertheless, the journey towards innovation carries its own complexities, particularly when it comes to its impact on a company's perceived value in the eyes of external investors. The inherent information asymmetry that plagues the evaluation of innovative enterprises can pose challenges for investors seeking to gauge the true worth of such firms. It's often a daunting task to assign value to companies with uncharted territories, prompting investors to adopt precautionary measures. These measures typically involve relying on indicators of a company's quality to assess its potential and mitigate risks (Certo, 2003). When a company embarks on the path of an IPO, it gains the opportunity to shape investor perceptions and bolster trust by signaling its legitimacy and competence(Brau & Fawcett, 2006; Certo, 2003) . Patents, as tangible evidence of invention and expertise, can serve as a particularly potent quality signal when ambiguity and information asymmetry are effectively minimized within the IPO process, ultimately enhancing investor confidence and paving the way for successful capital raising endeavors.

While the mainstream literature has predominantly focused on patents as instruments for protecting intellectual property and securing monopolistic rights, their role as signals of a company's quality should not be underestimated. Patents serve a multifaceted purpose in the corporate landscape. On one hand, they are indeed crucial for safeguarding a company's technological innovations and creating barriers to entry (Schankerman, 1998). They provide businesses with the legal framework to protect against infringements and maintain exclusive rights to profit from their unique product offerings (Graham & Sichelman, 2008). Additionally, patents facilitate cross-licensing agreements, fostering collaboration in industries driven by innovation (Hall & Ziedonis, 2001); (Motohashi, 2008).

However, patents extend beyond their legal and protective functions; they also play a pivotal role in mitigating informational asymmetries between companies and external investors. A company's patent portfolio serves as tangible evidence of its capacity to synthesize knowledge and reflects the caliber of its technological advancements (Hall & Helmers, 2019). Moreover, patents offer insights into a company's distinctive product offerings, including the number of product lines and the stage of development of its product candidates (Deeds et al., 1997; W.-C. Guo et al., 2012). In essence, patents become a potent tool for signaling technical competency. A business armed with a robust patent portfolio is often perceived by outsiders as better equipped to not only safeguard its profits but also potentially enhance them in comparison to its competitors.

Given the significance of patents in conveying technical expertise and quality, many businesses go to great lengths to acquire patents, particularly as they prepare for IPO. The IPO process presents a unique opportunity for companies to enhance their reputation and perceived value among investors. By showcasing their patent holdings, businesses can bolster their image, instill confidence, and project themselves as formidable players in their respective industries. Consequently, patents, serving both as protective mechanisms and powerful signals of competence, assume a critical role in shaping investor perceptions and facilitating successful capital-raising endeavors, especially during the transformative phase of an IPO.

Drawing from Spence's signaling theory, it becomes evident that firms of higher quality actively choose to deploy signals, whereas their lower-quality counterparts might refrain from doing so due to the prohibitively high costs associated with mimicking effective signals. Patents emerge as a quintessential high-quality signal, grounded in several compelling conditions. Firstly, a firm's patent portfolio stands as a tangible testament to its proficiency in the realms of science and engineering expertise (T. Wang et al., 2019). Secondly, the very process of acquiring patents is a costly endeavor, encompassing expenses linked to initiating patent applications, validating those applications, and maintaining the granted protections over time (De Rassenfosse et al., 2013). Furthermore, patents are not indiscriminately bestowed; they are exclusively awarded for genuinely innovative technologies and only to the original party that can substantiate its rightful legal claim to these innovations (Levitas & McFadyen, 2009). This intrinsic selectiveness serves as a stark delineation between high-quality enterprises and their lower-quality counterparts, effectively demarcating their capacity to navigate the innovation landscape adeptly. In addition, the transparent nature of patent applications renders their contents accessible to the public domain (Hall et al., 2005). This open accessibility transforms patent information into a valuable resource for external investors, providing them with a means to gauge a company's intrinsic worth reliably and cost-effectively. In essence, patents, as high-quality signals, not only signify competence and innovation but also serve as a potent tool for minimizing information asymmetry in the realm of finance, thus bolstering investor confidence and facilitating informed investment decisions.

The utilization of patents as a signaling mechanism to financial markets has attracted substantial empirical scrutiny over the past two decades, with a plethora of studies delving into this concept. **Table 4.1** provides a comprehensive overview of these investigations on patent signaling. (Baum & Silverman, 2004) found that all three facets of firm resources—patents, partnerships, and team experience—exhibit a positive correlation with the level of venture capital funding. Specifically focusing on venture-backed software companies, (Mann & Sager, 2007) observed that patents exerted a discernible influence on overall funding in this sector.

Table 4.1 Summary of study on patent signal

Paper	Author	Year	Sample	Sectors	Signal	Insight
How do technology ventures signal IPO quality? A configurational approach	(T. Wang et al., 2019)	2019	IPOs ventures in the US	Biotechnology	Patent citation	Technology ventures signal IPO quality by sending quality signals in the areas of technology development, venture officers, and early investors, which collectively reduce information asymmetry and complement each other.
Commercialization Strategy and IPO underpricing	(Serena Morricone et al., 2017)	2017	IPOs companies in the US	Semiconductor industry	Patent granted	Patents mitigate the effect of licensing strategy on underpricing.
Do patents affect VC financing? Empirical evidence from the nanotechnology sector	(Munari & Toschi, 2015)	2015	VC-backed companies	Nanotechnology	Patent application	The number of patents in the nanotechnology sector has a positive and significant effect on VC financing, especially for specialized VCs.
Quality signals? The role of patents, alliances, and team experience in venture capital financing	(Hoenig & Henkel, 2015)	2015	German and US VCs	High-technology	Patent application Patent granted	Patents and team experience are seen as signals of technological quality by venture capitalists, while alliances also play a role.
How patenting informs VC investors- The case of biotechnology	(Häussler et al., 2012)	2014	United Kingdom and German VC	Biotechnology	Patent application	Filing patent applications positively affects VC financing and Patent examination process

						provides valuable information for VC financing.
Are patents signals for the IPO market? An EU-US comparison for the software industry	(Useche, 2014)	2014	US and EU IPO companies	Software	Patent application	Patents can be signals for the IPO market. The study found that an additional patent application prior to IPO increases IPO proceeds by about 0.507% and 1.13% for US and European companies, respectively.
Small firms, big patents? Estimating patent value using data on Israeli start-ups' financing rounds	(G. Greenberg, 2013)	2013	Israel start-ups	Semiconductors, Communications, Life sciences, Cleantech, IT & enterprise software, and Internet.	Patent application Patent grant	Patent applications positively impact start-up valuations in non-software industries while granting of patents enhances investors' perception of firm value.
The information role of patents in venture capital financing	(J. Cao & Hsu, 2011)	2011	VC-backed start-up firms	Computer-related	Patent application	Start-ups with successful patent applications have higher success probability.
Patent commercialization Strategy and IPO Underpricing: Evidence from the US Semiconductor Industry	(SERENA Morricone et al., 2010)	2010	US IPO companies	Semiconductor	Patent application	The patent commercialization strategy of a firm going public affects information asymmetries and IPO underpricing in the semiconductor industry, in particular, underpricing will be higher when a firm's patent commercialization strategy is more based on licenses.

To be financed or not. The role of patents for venture captial-financing	(Häussler et al., 2012)	2009	German and British VC	Biotechnology	Patent application	Patents held by new ventures improve their ability to attract venture capital financing by serving as signals of potential success.
Patents as quality signals for entrepreneurial ventures	(Hsu & Ziedonis, 2008)	2008	US start-ups	Semiconductor	Patent application patent citation	Patents positively affect investors' perceptions of start-up quality, patents increase the likelihood of receiving initial backing from a prominent venture capitalist.
Patents, venture capital, and software start-ups	(Mann & Sager, 2007)	2007	US VC-backed	Software	Patent application Patent granted	Positive correlation between patenting and firm performance
Picking winners or building them? Alliance, intellectual, and human capital as selection criteria in venture financing and performance of biotechnology startups	(Baum & Silverman, 2004)	2004	Canada startups	Biotechnology	Patent application Patent granted	VC firms emphasize picking winners or building winners by comparing the effects of startups' alliance, intellectual, and human capital characteristic

In a rigorous examination conducted by Cao and Hsu (2011), which encompassed a vast sample of 20,000 venture capital-backed enterprises in the United States, the findings revealed that the quantity of patent filings preceding the infusion of venture capital funds was associated with more substantial investments and a diminished likelihood of business failure. Notably, the impact of patents becomes even more pronounced in the context of IPOs, where the number of patent applications filed prior to the IPO directly correlates with the magnitude of capital invested. This phenomenon held true across various subsamples, including 234 U.S. IPOs and 242 EU IPOs within the software industry, as elucidated in Useche's (2014) study.

Upon a comprehensive examination of the studies presented in Table 1, a conspicuous pattern emerges. The preponderance of research in this domain has honed in on venture capital-backed enterprises, primarily within technology-intensive sectors such as software, semiconductors, biotechnology, nanotechnology, and the internet. Moreover, a notable trend is the proclivity toward exploring risk-tolerant markets, exemplified by the United States, the United Kingdom, Germany, and Israel, where investors exhibit a higher threshold for risk in pursuit of commensurate returns. However, a conspicuous gap in the literature remains—there is a conspicuous absence of studies investigating the role of IPO proceeds as a proxy within the context of Japan, a markedly risk-averse market.

This study, therefore, makes a significant contribution to the existing body of research by embarking on an expansive exploration encompassing a diverse spectrum of Japanese IPO companies, spanning both manufacturing and non-manufacturing sectors. The overarching objective is to scrutinize whether patents serve as effective instruments in mitigating uncertainty and information asymmetry, thereby emitting favorable signals to the market and facilitating the IPO process. Consequently, the formulation of the following hypothesis is imperative:

Hypothesis 1: ***All other conditions being equal, the patents before IPO signal IPO performance***

4.3. Data Collection and Methodology:

4.3.1. Data collection:

Our research endeavor entailed the meticulous construction of a comprehensive dataset, a critical foundation for our investigative journey. This dataset was meticulously assembled to encompass IPO deals executed during a specific timeframe, ranging from 1 January 2000 to 31 December 2015. Our inclusivity criterion extended to all firms operating within Japan, both manufacturing and non-manufacturing, and these firms were identified through the Japan Exchange Group (JPX) database. The selection of this temporal window was judiciously made, taking into account factors such as market stability, the regulatory landscape governing signaling practices, and transparency.

Central to our dataset were patenting data, acquired through a scrupulous process of manual extraction from the Japan Platform for Patent Information (JplatPat). To ensure the relevance and specificity of our dataset, we adopted a stringent approach. Firms devoid of any patent applications at the time of their IPO were excluded, as our focus rested squarely on enterprises exhibiting active innovation endeavors. Additionally, companies pursuing a "trade-secret" strategy were deliberately omitted from our analysis, as this fell beyond the purview of our current research objectives. Complementing our patent data, we sourced IPO-related information from Thomson Reuters Eikon. This encompassed essential details such as the proceeds generated, the underwriting arrangements, and the stock market in which the IPO was conducted. To enrich our dataset with pertinent pre-IPO performance metrics, we leveraged the FinancialQuest database. Notably, this database furnished us with crucial indicators, including the number of employees, the debt-to-equity ratio, and the age of the firms. In our classification scheme, we distinguished between high-tech and low-tech firms, employing the internationally recognized standard industrial classification proposed by the Organization for Economic Co-operation and Development (OECD). This classification facilitated a nuanced analysis of firms based on their technological orientation.

With meticulous attention to data integrity and precision, we further refined our dataset by retaining only companies for which information was readily available. To enhance the robustness of our analysis, we prudently identified and removed outlier data points. Consequently, our final sample comprises a cohort of 338 newly listed Japanese IPO firms, forming the bedrock upon which our research insights are founded.

4.3.2. Variables:

- ***Dependent Variables:***

IPO finance performance: In our pursuit of comprehensively assessing the success of an IPO in term of finance from the perspective of the company undergoing this transformative financial event, a pivotal dependent variable takes center stage in our research framework. This essential metric, which we denote as "Proceeds" (PROCEED), serves as a robust yardstick to gauge the performance and efficacy of the IPO process. The utilization of Proceeds as a primary indicator finds resonance in established research practices and is underpinned by the work of previous scholars ((T. Wang et al., 2019); (Useche, 2014); (Khoury et al., 2013); (M. J. Higgins et al., 2011); (Aggarwal et al., 2009); (Certo et al., 2009); (Li and Bruce, 2004). To provide further clarification, proceeds refer to the whole financial inflow obtained by a company via its IPO efforts. This calculation is derived by multiplying the number of shares issued by the firm with the per-share issue price established on the day of the IPO. The deliberate selection of Proceeds as our primary metric holds notable advantages. It effectively circumvents potential concerns related to the allocation of resources and finances that could introduce biases when attempting to compute pre-money valuations (Ritter & Welch, 2002).

- ***Independent Variables:***

Patent Stock: To gauge a firm's patenting activity in the lead-up to an IPO, we employ a metric known as "Patent Stock." This crucial measure encapsulates the total number of patent applications filed by the company as of the IPO date. Our approach in quantifying this variable draws inspiration from the methodologies adopted by prior researchers such as (Useche, 2014) and (SERENA Morricone et al., 2010). In our analysis, we create two distinct variables, namely PAT4 and PAT5, each providing distinct insights into the firm's patenting activity leading up to the IPO. PAT4 captures the number of patents filed by the company during the four years immediately preceding the IPO, while PAT5 extends this horizon to encompass the five years prior to the IPO date. The rationale behind employing these specific timeframes is grounded in the dynamics of patent protection, which typically grants a 20-year safeguard from the date of filing. It's imperative to underscore the importance of focusing on recent patent applications within this context. The reasoning behind this is twofold. Firstly, older patents may not accurately reflect a company's current state of innovation performance, as innovation is an evolving and dynamic process (Heeley et al., 2007). Secondly, recent patent applications provide a more up-to-date and pertinent snapshot of an organization's innovative capacity at the time of an IPO (Useche, 2014).

By incorporating both PAT4 and PAT5 into our regression analysis for our key independent variables, we aim to provide a more comprehensive and nuanced understanding of how the timing and volume of patent applications influence the success of IPOs. This approach ensures that we capture the most relevant and informative aspects of a company's patenting activity in the context of a significant financial event such as an IPO.

- ***Control Variables:***

Firm Size: This measure encapsulates the scale of a firm offering valuable insights into how the magnitude of an organization may affect its IPO outcomes. Our computation of firm size, denoted as SIZE, is derived by taking the natural logarithm of the total number of employees the firm had in the year immediately preceding its IPO. This approach aligns with established practices in financial research (Welbourne & Andrews, 1996) and has been widely adopted to gauge the size dimension of firms. It is important to note that larger firms, as indicated by a higher SIZE, tend to exhibit better performance relative to their smaller counterparts (Ritter & Welch, 2002). By incorporating firm size into our analysis, we aim to shed light on how the scale of an organization may contribute to the success or performance of an IPO.

Firm Age: To evaluate the impact of a firm's age on its IPO performance, we employ the metric known as "Firm Age." This metric provides valuable insights into how the maturity or longevity of a business may influence its outcomes during an IPO. The calculation of firm age, denoted as AGE, is achieved by taking the natural logarithm of the time interval between the year in which the IPO occurred and the year when the business was initially founded. This approach aligns with established practices in financial research (Ritter, 1998) and is commonly used to assess the age dimension of firms. As a general trend, older businesses tend to outperform newer ones (Ritter, 1998). By incorporating firm age into our analysis, we seek to examine how the historical trajectory and experience of a firm, as indicated by its age, may impact the outcome of an IPO. This allows us to explore whether a longer track record in the market contributes to a more successful IPO performance.

Financial Ratio: In assessing the financial stability of a firm, we rely on a crucial indicator: the leverage ratio, specifically the debt-to-equity ratio, in the year immediately preceding the IPO. This financial metric, denoted as D/E RATIO, serves as a pivotal measure for evaluating a company's financial soundness and its capacity to manage financial risks effectively. The debt-to-equity ratio is calculated by dividing a firm's total debt by its total equity. A lower ratio typically indicates a more stable and less risky financial structure. This ratio is particularly insightful because it sheds light on the balance between a company's borrowed capital (debt) and the capital contributed by its shareholders (equity). To account for the skewed distribution of this data, we apply a natural logarithm transformation to the D/E RATIO. This transformation allows us to address the non-normality of the data, ensuring that our analysis provides accurate insights into how a firm's financial stability, as reflected in its leverage ratio, influences its performance during the IPO process.

High-tech Dummy: In order to differentiate between high-tech and traditional firms, we have developed a method using two dummy variables based on the OECD's international standard industrial classification, which classifies industries according to their research and development (R&D) intensity. This classification, outlined in **Appendix 3** for reference, categorizes sectors as either high-tech or low-tech based on their R&D expenditure as a percentage of total revenue. Specifically, industries with an R&D intensity exceeding 5% are classified as high-tech, while those falling below this threshold are categorized as low-tech. To operationalize this distinction, we have created the HILO_DUMMY variable, which takes on a value of "1" for high-tech IPOs and "0" for low-tech IPOs. This classification allows us to account for the distinct characteristics and dynamics that often differentiate high-tech and traditional firms in the context of IPOs, contributing to a more nuanced analysis of our data.

Underwriter Reputation Dummy: To gauge the impact of underwriter reputation on IPO performance, we have introduced the UW_DUMMY variable into our model. This variable serves as an indicator, taking on a value of "1" if the underwriter is among the top five Japanese underwriters, namely Mizuho, Nomura, Daiwa, Mitsubishi UFJ Morgan Stanley, or SMBC Nikko, as per Statista's rankings **(Appendix 4).** In cases where the underwriter does not belong to this top tier, the UW_DUMMY variable is assigned a value of "0". The inclusion of this variable allows us to assess whether the reputation of the underwriter, particularly one of the top-ranking firms, influences the success and outcome of an IPO. High-ranking underwriters are often associated with signaling a high-quality offering, which can enhance investor confidence and positively impact the IPO's performance. By examining the presence of such reputable underwriters in our dataset, we aim to explore their potential role in shaping the results of our analysis.

Stock Exchange Dummy: In our model, we have introduced the STOCK_DUMMY variable to account for the influence of the stock exchange on which the IPO firm's shares are listed. This variable serves as an indicator, taking a value of "1" if the firm is listed on the Tokyo Stock Market (TSE) **(Appendix 5)** , which is the largest stock exchange in Japan. Conversely, it is assigned a value of "0" for all other companies listed on different exchanges. This variable allows us to investigate whether the choice of stock exchange has any discernible impact on investor decisions and, consequently, on the outcome of the IPO. The exchange on which a company's shares are traded can play a significant role in shaping investor perceptions and behaviors, making it a relevant factor to consider in our analysis.

Venture Capitalist Backing Dummy: In our analysis, we have included the VC_DUMMY variable to examine the influence of venture capital backing on IPO performance. This binary variable is assigned a value of "1" for IPOs that have received backing from venture capitalists and "0" for those without such backing. Venture capital support is an important factor to consider since it has been shown to significantly affect the fundraising capabilities of IPO-bound companies. Prior research has highlighted the positive impact of venture capital backing on the success of IPOs, emphasizing the role of these investors in providing financial support and strategic guidance to emerging firms. Therefore, by including the VC_DUMMY variable, we aim to explore whether venture capital backing contributes to the performance of IPOs in our dataset.

Year Dummy: To address IPO-specific trends that may vary over time, we have incorporated a comprehensive set of year dummies in our analysis, encompassing the years from 2000 to 2015. These year dummies, labeled as "Year2000" through "Year2015," enable us to capture any time-related variations or effects that might impact the performance of IPOs. By including these year dummies, we account for the changing dynamics of the IPO market throughout the specified period, ensuring that our analysis accurately reflects the unique circumstances of each year and allows us to assess the impact of these temporal factors on IPO outcomes. This comprehensive approach enhances the robustness and thoroughness of our investigation into the relationship between patent signals and IPO performance.

The list of variables, relevant literature, and database are summarized in **Table 4.2.**

Table 4.2 Variable Definition

Variable	Definition	Database	Past Study
IPO performance* (PROCEED)	The amount of money raised by a firm via an IPO (million yen)	Thomson Reuter Eikon	(Useche, 2014) (Zimmerman, 2008)
Patent stock (PAT4) (PAT5)	Patent application by the company in the last 4 years prior to the IPO Patent application by the company in the last 5 years prior to the IPO.	Jplatpat	(Useche, 2014) (SERENA Morricone et al., 2010)
Firm Size* (SIZE)	Total number of employees at IPO	FinancialQuest	(Welbourne & Andrews, 1996)
Firm Age* (AGE)	Age of firm at IPO	FinancialQuest	(Z. Cao et al., 2022)
Financial Ratio* (D/E RATIO)	The ratio of debt to equity in the IPO year	FinancialQuest	(Herawati, 2017)(Guiso, 1998)
Hi-tech Dummy (HILO_DUMMY)	Dummy (1 if in high-tech industry and 0 if in low-tech industry)	OECD industrial classification Thomson Reuter Eikon classification	(Guiso, 1998) (Galindo-Rueda & Verger, 2016)
Underwriter Dummy (UW_DUMMY)	Dummy (1 if in the top 5 Japanese	Thomson Reuter Eikon, Statista	(Brau & Fawcett, 2006)

	underwriters, 0 otherwise)		
Stock Exchange Dummy (STOCK_DUMMY)	Dummy (1 if in TSE, 0 otherwise)	Thomson Reuter Eikon, Japan Exchange Group	(Useche, 2014)
Venture Capitalist backing Dummy (VC_DUMMY)	Dummy (1 if the firm is backed by the venture capitalist sector, 0 otherwise)	Thomson Reuter Eikon	(Certo et al., 2001)
Year Dummy Year2000 to Year2015	Dummies (from Year2000 to Year2015)	FinanicalQuest	(SERENA Morricone et al., 2010)

Note: (*) We applied log natural for the variable

4.3.3. Econometric Model:

In order to analyze whether patenting prior to the IPO impacts on the IPO performance, we first estimated the following OLS regression model in Equation 1 to test ***Hypothesis 1:***

Equation 1:

$$\text{PROCEED}_i = \beta_0 + \beta_1 \text{PATENT\_STOCK}_i + \beta_2 \text{CONTROL\_VARIABLES}_i + \varepsilon_i \quad (1)$$

Where:

- PROCEED: the amount of money that a company may raise on the day of its IPO;
- PATENT_STOCK: Patent application by a firm in the prior to the IPO. Where PATENT_STOCK is equal to PAT4 and PAT5 respectively;
- CONTROL_VARIABLES: set of control variables;
- ε: Statistical errors.

Hypothesis 1 argues that patent activities before IPO reduce information asymmetry between corporate insiders and external investors, and thereby improve the IPO performance; this suggests that the coefficient of PATENT_STOCK_i is greater than zero ($\beta_1 > 0$).

4.4. Result and Discussion:

4.4.1. Premilinary Analysis:

Figure 4.1 provides an insightful analysis of the evolving landscape of IPO activity from 2000 to 2015. During this period, the number of IPO firms exhibited significant fluctuations, reflecting the dynamic nature of the market. In the initial half of the analyzed period, there was a notable upswing in the number of companies choosing to go public. This surge can be attributed to various factors such as economic optimism, favorable market conditions, and an increased appetite for investments in emerging ventures. The detail of Preliminary Analysis result is present in **Appendix 6**

However, the trajectory of IPO activity took a sharp turn in 2008, coinciding with the onset of the global economic crisis. This pivotal year marked a substantial decline in the number of companies embarking on IPOs. The reverberations of the Great Recession were felt worldwide, and Japan was no exception, with the IPO market bearing the brunt of this economic turmoil. The subsequent years, particularly since 2013, witnessed a modest recovery in the number of IPO companies. This rebound aligns with the broader economic recovery both within Japan and on a global scale, signifying a gradual resurgence in investor confidence and market stability.

Overall, **Figure 4.1** illustrates the intricate interplay between economic events, market conditions, and IPO activity. It underscores the impact of macroeconomic forces on the decision-making processes of companies considering public offerings, providing valuable context for our study of patent signals and IPO performance in the Japanese market during this transformative period.

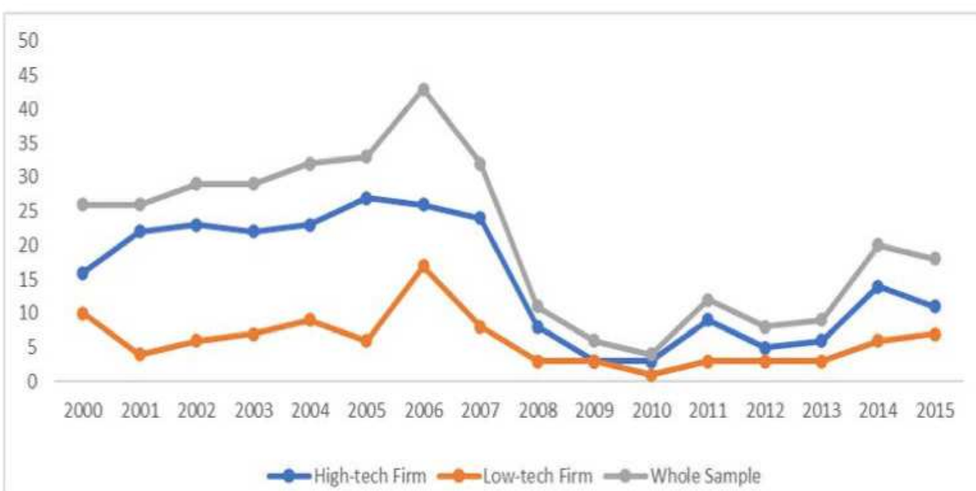


Figure 0.1 Distribution of Japanese IPOs across the years

Table 4.3 presents the descriptive statistics presented in the table offer valuable insights into the key covariates used in our study, comprising a comprehensive sample of 338 firms. These statistics shed light on the central variables that shape the dynamics of IPO performance in the Japanese market.

First and foremost, the mean Proceeds (PROCEED) value of 4878.916 with a standard deviation of 12479.669 underscores the substantial variability in the amount of capital raised by firms through IPOs. This variance reflects the diverse financial goals and strategies pursued by these companies. Turning to the patent-related variables, PAT4 and PAT5, the means of 69.160 and 56.038, respectively, reveal that firms tend to file a considerable number of patents in the years leading up to their IPOs. This suggests a proactive approach to intellectual property protection and innovation, which may serve as a signal to potential investors.

In terms of firm characteristics, SIZE exhibits a mean of 974.956, emphasizing the wide-ranging scale of companies going public, with some being significantly larger than others. Additionally, the mean AGE of 26.760 indicates that there is a mix of both established and relatively newer firms entering the IPO market.

Examining financial stability, the mean Debt-to-Equity Ratio (D/E Ratio) of 2.331 suggests that, on average, firms maintain a moderate level of leverage, with some displaying higher degrees of financial risk.

Table 4.3 Descriptive Statistic

Covariate	Full sample (N=338)	
	Mean	Standard Deviation
PROCCED	4878.916	12479.669
PAT4	69.160	303.077
PAT5	56.038	404.200
SIZE	974.956	3096.394
AGE	26.760	20.565
D/E Ratio	2.331	4.038
HILO_DUMMY	0.716	0.452
UW_DUMMY	0.772	0.420
STOCK_DUMMY	0.222	0.416
VC_DUMMY	0.361	0.481

The presence of the HILO_DUMMY, UW_DUMMY, STOCK_DUMMY, and VC_DUMMY variables highlight the diversity in firms' characteristics, including their tech classification, underwriter reputation, stock exchange listing, and venture capitalist backing. About 22% of total IPO firms are listed in the biggest Japanese stock exchange (Tokyo stock exchange); the remaining firms are listed in the JASDAQ Exchange, Mother Exchange, Osaka exchange, and other exchanges. 77% of Japanese IPOs in the current setting choose to work with the most prestigious underwriter to help the company prepare for the IPO.

In summary, these descriptive statistics provide a comprehensive overview of the covariates underpinning our study, revealing both the heterogeneity and commonalities among the firms in our sample. This diversity sets the stage for a rigorous examination of the impact of patent signals on IPO performance in the Japanese context, considering the interplay of these covariates.

Table 4.4 presents a comprehensive correlation analysis that offers valuable insights into the relationships among the key variables in our model. Notably, we focused on the independent variable "Patent Stock," represented by both PAT4 and PAT5, which capture the number of patents filed by firms in the years leading up to their IPO. One prominent observation is that most of the correlations reported in both tables fall within the range of low to medium significance. This suggests that, in our model, the variables exhibit relatively modest interdependencies, with no strong linear relationships dominating the dataset.

However, it is noteworthy that the highest correlation value of 0.510 is consistently reported between firm Size (SIZE) and Stock Exchange Dummy (STOCK_DUMMY) in both tables. This correlation is not unexpected, as the Tokyo Stock Exchange, being the largest in Japan, tends to attract larger firms for listing. This finding underscores the importance of considering the stock exchange choice as a factor potentially linked to firm size. Importantly, our analysis reveals that correlations among the independent variables, including PAT4 and PAT5, remain comfortably below the 0.900 cut-off point. This signifies that there is no evidence of severe multicollinearity, which is essential for ensuring the validity of our regression analysis. In other words, our model is not plagued by excessively high correlations among the independent variables, reducing the risk of multicollinearity-related biases.

In summary, the correlation matrixes in **Table 4.4** provide a thorough assessment of the relationships between our key variables, affirming the robustness of our model and its suitability for investigating the impact of patent signals on IPO performance in the Japanese context.

Table 4.4 Correlation Matrix

	PATENT_STOCK= PAT 4								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Proceed (1)	1								
PAT4 (2)	0.529	1							
SIZE (3)	0.472	0.311	1						
AGE (4)	-0.051	-0.117	0.370	1					
D/E Ratio (5)	0.045	0.041	0.315	0.372	1				
HILO_DUMMY (6)	0.084	0.056	-0.063	-0.114	-0.125	1			
UW_DUMMY (7)	0.066	0.015	0.098	0.171	0.037	0.033	1		
STOCK_DUMMY(8)	0.380	0.229	0.510	0.241	0.148	0.067	0.188	1	
VC_Backed(9)	-0.055	-0.023	-0.234	-0.115	-0.182	-0.032	0.099	-0.193	1
	PATENT_STOCK= PAT5								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Proceed (1)	1								
PAT5 (2)	0.497	1							
SIZE (3)	0.472	0.294	1						
AGE (4)	-0.051	-0.119	0.370	1					
D/E Ratio (5)	0.045	0.036	0.315	0.372	1				
HILO_DUMMY (6)	0.084	0.055	-0.063	-0.114	-0.125	1			
UW_DUMMY (7)	0.066	0.018	0.098	0.171	0.037	0.033	1		
STOCK_DUMMY(8)	0.380	0.211	0.510	0.241	0.148	0.067	0.188	1	
VC_Backed(9)	-0.055	-0.026	-0.234	-0.115	-0.182	-0.032	0.099	-0.193	1

4.4.2. Main Analysis:

Regression results are presented in **Table 4.5** using two Panels. Panel I report regression results where PAT4 is used as an independent variable. Panel II shows results on the usage of PAT5 as an independent variable. The full regression result is presented in **Appendix 7.**

The analysis undertaken to test Hypothesis, which delves into the relationship between IPO performance and patent signaling effects, yielded significant results as outlined in Equation (1). In **Model 1** and **Model 3**, the coefficients associated with PAT4 and PAT5, respectively, displayed noteworthy patterns. Both coefficients carried positive values, standing at 0.0005 with a 5% significance level for PAT4 in Model 1 and 0.0003 with a 5% significance level for PAT4 in Model 3.

These findings can be interpreted as follows: for each additional log patent application submitted by a firm four years before its IPO, there is an associated increase of 0.5% in the total proceeds collected at IPO, all other factors held constant. Similarly, each additional log patent application filed five years before the IPO results in a 0.3% increase in the total IPO proceeds under the same conditions. These outcomes provide compelling support for ***Hypothesis 1***.

Traditionally, the literature has emphasized that the primary purpose of patent filing is to safeguard innovation against infringement and enhance a company's competitive edge. However, our findings contribute an intriguing dimension to this discourse. We propose that patents can also serve as signals to prospective lenders and investors, facilitating easier access to external financing.

Moreover, the results presented in **Table 4.5** uncover an intriguing trend. They suggest that as a firm approaches its IPO date, the likelihood of a successful IPO increases. This insight is gleaned from the comparison between the coefficients of PAT4 in Model 1 (0.0005) and PAT5 in Model 3 (0.0003). This pattern implies that Japanese IPOs may strategically leverage patents as signals of technological advancement to mitigate information asymmetry with external investors. Consequently, companies intensify their patent-related activities as they draw nearer to their IPO, ultimately enhancing their performance and, consequently, the total capital raised during the IPO event.

Table 4.5 Result of main analysis

	Panel I STOCK_PATENT = PAT4 Model 1	Panel II STOCK_PATENT=PAT5 Model 3
Intercept	5.7756*** 0.391	5.7679*** 0.391
PAT4	0.0005** 0.000	
PAT5		0.0003* 0.000
SIZE	0.3871*** 0.058	0.3917*** 0.058
AGE	-0.3537*** 0.093	-0.3592*** 0.093
D/E RATIO	-0.0575 0.062	-0.0569 0.063
HILO_DUMMY	0.3203** 0.151	0.3221** 0.152
UW_DUMMY	0.2776* 0.166	0.2750* 0.166
STOCK_DUMMY	0.4890** 0.193	0.4982** 0.193
VC_DUMMY	-0.1517 0.147	-0.1470 0.147
YEAR_DUMMY	Yes	Yes
Adj_R_square	0.273	0.272
F-STATISTIC	16.84	16.72
PROB(F-STATISTIC)	5.96e-21	8.34e-21
Observation	338	338

Note: Values are regression coefficients with t-statistic in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The slope coefficients of the control variables align with the findings of previous studies, offering valuable insights into the factors influencing IPO performance. At the 1% significance level, all models consistently reveal a positive relationship between firm size and Total Proceed. This suggests that larger companies tend to command higher IPO valuations. Investors perceive larger IPOs as less risky compared to smaller ones, attributing to them a greater likelihood of achieving success in their public listing. This observation aligns with the conclusions drawn in earlier research (Chahine & Goergen, 2013; Gu, 2003; Useche, 2014).

Surprisingly, the relationship between Total Proceed and a company's age is negative, contrary to initial expectations. One plausible explanation is that a firm's age is associated with increased ex ante uncertainty. As a result, older companies may experience a negative association with Total Proceed, as shorter-term returns often favor younger firms linked to higher uncertainty levels. This finding resonates with the results of (Ahmad-Zaluki & Kect, 2012) in their examination of various IPO markets.

The impact of a firm's financial stability, measured by its debt-to-equity ratio, exhibits a positive but statistically insignificant association. This suggests limited evidence supporting a strong link between a company's stability and its IPO success. However, it's worth noting that the underwriter's reputation plays a significant and positive role in predicting a successful IPO outcome, consistent with the findings of (Carter et al., 1998) and (An & Chan, 2008)

Additionally, the study identifies Stock Dummy as a significant and positive factor affecting IPO performance, with a p-value of 0.010. This observation underscores the importance of the stock exchange on which the IPO firm's shares are listed. The Tokyo Stock Exchange, in particular, serves as a trading platform for well-established and renowned firms, attracting substantial investments from investors who have confidence in these companies' continued strong performance.

Interestingly, the influence of venture capital backing is found to be statistically insignificant. Therefore, it can be concluded that Japanese companies backed by venture capital do not experience a significant impact on their success in the IPO process.

4.5. Summary

This research makes a substantial contribution to the literature concerning the interplay of patents, innovation, and financial success, particularly in the context of initial public offerings. It delves deeper into the motivations for patenting within entrepreneurial firms, emphasizing the role of patents as signals that bridge information gaps between companies and investors, facilitating the acquisition of external financial capital. Notably, this study broadens its scope by focusing on Japanese IPO firms spanning diverse industries. Analyzing a comprehensive dataset, the research uncovers that patents maintain their efficacy as signals even within risk-averse markets, such as Japan, where they effectively reduce information asymmetry. This expansion not only enhances the empirical underpinning of patent-signaling research but also provides novel insights into how firms strategically leverage patents in the context of IPOs across a variety of sectors and regions.

CHAPTER 5:

DOES PATENT SIGNALING VARY CONTIGENTLY UNDER TECHNOLOGY INTENSITY? EVIDENCE FROM HIGH-TECH AND LOW-TECH IPO IN JAPAN

5.1. Introduction:

In the ever-evolving landscape of corporate finance, the Initial Public Offering represents a pivotal moment in the life of a company. Beyond the allure of transitioning from private to public ownership, the IPO serves as a gateway for firms to secure essential financial resources that drive their growth, innovation, and market competitiveness (Motohashi, 2008)However, this journey to a successful IPO is fraught with complexities, where the signals a company emits to potential investors can profoundly impact its outcome (W. M. Cohen et al., 2000). In the preceding chapter, we successfully demonstrated that Japanese companies effectively utilize patents as signals to reduce information asymmetries between the company and investors, instilling confidence in investors regarding a firm's technological prowess and future prospects, thereby facilitating the acquisition of external financial capital (Graham & Sichelman, 2008). Patents provide tangible evidence of a company's commitment to innovation, safeguarding its intellectual property and establishing a competitive advantage in a fiercely competitive marketplace (W. M. Cohen et al., 2000)

Nevertheless, the effectiveness of patent signaling is far from uniform across all industries, and it is contingent upon the specific sector to which a company belongs, a factor that has garnered relatively little attention in prior research (Motohashi, 2008). In this context, this chapter aims to delve into the intriguing dynamics of patent signaling within the context of IPO firms, distinguishing between high-tech and low-tech sectors. While it is widely acknowledged that information asymmetry associated with Research and Development (R&D) and patent activity disclosure is more pronounced in high-tech industries than in low-tech sectors (Prędkiewicz et al., 2021), the nuances and implications of these differences for IPO performance have remained relatively uncharted territory.

High-tech and low-tech companies, despite sharing the common goal of innovation, exhibit fundamental disparities in their operations and financial characteristics (J. Kim et al., 2008). High-tech firms, often engaged in complex innovation projects to maintain a competitive edge through advanced technological breakthroughs, frequently yield a significant number of patents to protect their intellectual property (Leone et al., 2007). However, the intricacies of such patents may render them less comprehensible to external observers (J. Kim et al., 2008). Moreover, high-tech firms frequently allocate substantial resources to innovation endeavors that, in their early stages, may yield minimal or no profits, amplifying the risk for potential investors (S. Gao & Hou, 2019). This inherent unpredictability in deriving profits from innovation initiatives contributes to the perceived risk of financing high-tech firms (Coad et al., 2016; Mazzucato, 2013)

Furthermore, high-tech companies often boast significant intangible assets, primarily in the form of patents and intellectual property, compared to their low-tech counterparts, which tend to allocate their resources more evenly (J. Kim et al., 2008) Financing these technology-centric projects necessitates specialized expertise, posing a formidable challenge for most investors (Prędkiewicz et al., 2021). This unpredictability in reaping rewards from innovation makes financing such ventures a considerably riskier proposition. Consequently, the asymmetry of information surrounding the technological sophistication and innovative pursuits of high-tech companies places significant constraints on their ability to secure investments.

In contrast, low-tech firms, while possessing fewer patents, often harbor patents of substantial value, readily discernible through product development and operational activities (J. Kim et al., 2008). Consequently, they transmit clear and positive signals to prospective investors in the lead-up to an IPO. These firms adopt a more balanced resource allocation strategy, which is inherently less dependent on cutting-edge technological advancements. This simplicity in their business models and product offerings makes them more accessible to a broader range of investors, who may not possess the specialized knowledge required to assess the intricacies of high-tech ventures (Prędkiewicz et al., 2021).

This divergence between high-tech and low-tech IPOs raises a critical question: are high-tech firms less successful than their low-tech counterparts in using patent signals to raise total capital during the IPO process? This question is vital because the characteristics of high-tech and low-tech firms are often ignored in prior studies on IPOs, as all IPOs are typically bundled together (J. Kim et al., 2008). Moreover, previous literature, while exploring the patent signaling phenomenon, has predominantly focused on high-tech firms in technology-intensive sectors, mainly within risk-tolerant markets like the United States and Europe. Remarkably absent from this discourse is an exploration of patent signaling's significance within Japan's more risk-averse landscape, particularly across a spectrum of industries encompassing both manufacturing and non-manufacturing sectors (Matsuura et al., 2022). Furthermore, scant attention has been paid to the differential impact of patents on IPO success in high-tech and low-tech contexts, further underscoring the novelty of this inquiry.

Against this backdrop, this chapter endeavors to fill the critical gap in the existing literature by rigorously investigating the interplay of patent signaling, technology intensity, and IPO performance in the Japanese context (J. Kim et al., 2008). Through the examination of a comprehensive sample of Japanese IPO companies spanning diverse industry sectors, this research seeks to unearth the nuanced ways in which patents serve as signals to alleviate information asymmetry, thus influencing the outcomes of IPOs (S. Gao & Hou, 2019). Through this endeavor, we aim to contribute fresh insights that shed light on the unique dynamics of patent signaling in Japan, thereby enhancing our understanding of the critical intersection of technology and finance within the IPO landscape (Matsuura et al., 2022)

In this chapter, we continue our empirical research, utilizing data from 338 Japanese IPOs, comprising 242 high-tech firms and 96 low-tech firms listed between 2000 and 2015. Employing the OECD industrial categorization to differentiate between high-tech and low-tech sectors, we apply Original Least Square Regression. Our findings indicate that the interaction effect between the high-tech dummy and the number of patent applications prior to an IPO is considerably negative concerning the capital collected at IPO. When applying an alternative industrial categorization provided by Thomson Reuters to our sample, the findings hold true for a new set of high-tech and low-tech firms, which leads us to conclude that, for Japanese companies belonging to the high-tech industry sector, patenting activities fail to provide a positive signal for IPO success (Prędkiewicz et al., 2021). In contrast, Japanese companies belonging to the low-tech industry sector tend to perform better during IPOs (J. Kim et al., 2008).

5.2. Literature Review and Hypothesis Development:

5.2.1. Literature review of previous studies:

This literature review aims to delve into the multifaceted dimensions of how patents influence various aspects of IPO outcomes. **Table 5.1.** summary the literature review articles.

One significant contribution to this field comes from a study by (Czarnitzki et al., 2014). Their research cast a wide net, examining a diverse panel of established firms across a broad spectrum of industries. Their findings illuminated a crucial insight: patents play a pivotal role in attenuating financing constraints, particularly benefiting small firms characterized by elevated information asymmetries and limited collateral value. Expanding upon this foundation, (L. J. Zhou & Sadeghi, 2019)' study ventured into the realm of pre-IPO innovations and their impact on short-term IPO performance. Drawing upon a dataset spanning 1460 IPOs across all industries listed on China's major stock exchanges, their analysis yielded intriguing results. They discovered that a higher number of patents held prior to IPOs was associated with shorter "honeymoon" periods, while increased research and development (R&D) spending correlated with greater IPO underpricing.

Narrowing the focus to the United States' semiconductor industry, (SERENA Morricone et al., 2010)'s research , in both 2010 and 2017, explored the influence of firms' technology commercialization strategies on information asymmetries and IPO underpricing. Their research revealed that underpricing tended to be higher when a firm's technology commercialization strategy leaned towards licenses. However, patents acted as a mitigating factor in this relationship, tempering the effect of licensing strategies on IPO underpricing.

Meanwhile, (Useche, 2014)'s research delved into how patenting behavior impacted investors' perceptions of software firms, particularly in the context of the amount invested during IPOs in the United States and Europe. His findings unveiled intriguing regional disparities in the signaling power of patents, with patents exerting a more significant impact on software IPOs in Europe.

Shifting the spotlight back to high-tech companies, (Vitt & Xiong, 2015) investigated the intricate relationship between patent activities of high-tech firms and the dynamics of their stock price movements. Their novel approach introduced a nuanced analysis, ultimately concluding that patent activities wielded a substantial impact on stock price movements.

In another avenue of exploration related to patent signaling and financial performance, (M. Greenberg, 2013)' study sought to estimate the value of patents for technological start-ups, specifically in Israel. The study provided empirical evidence that both granted patents and patent applications exerted a positive influence on start-up valuations across various sectors. Paper of (Smith & Cordina, 2015) delved into the importance of patenting to venture capital investors in high-technology firms. Through illuminating insights from active investors in the field, this research underscored the link between the existence of patents and the levels of investment attracted by these firms.

Expanding the scope, (Heeley et al., 2007)' research honed in on manufacturing firms in the United States. Their model demonstrated that innovation outputs, primarily in the form of patents, served to reduce information asymmetries in industries where the connection between patents and inventive returns was transparent. Consequently, this reduction in information asymmetry contributed to the mitigation of IPO underpricing.

Notably, despite the wealth of research in this domain, a discernible gap remains. The majority of studies either aggregate all IPOs into a single category or exclusively concentrate on high-tech sectors such as biotechnology, semiconductors, software, and life sciences. Surprisingly, there has been limited exploration of the impact of patenting activities on IPOs when firms are categorized into high- and low-tech industries. In response to this gap, our study seeks to make a significant contribution to the existing literature by examining how the signaling effect of patents differs between high-tech and low-tech firms in the context of Japanese IPOs. This endeavor promises to offer fresh insights into the intricate interplay between innovation, finance, and corporate success within the unique context of initial public offerings.

Table 5.1 Summary of Literature review

No	Paper	Authors	Sample	Sector (Hightech/lowtech)	Method Used	Result
1	Patents as Quality Signals? The Implications for Financing Constraints on R&D	Dirk, Czarnitzki., Bronwyn, H., Hall., Hanna, Hottenrott. (2014).	OECD countries	Broad range of industries	Tobit regression	-Patents attenuate financing constraints for small firms. - Larger firms do not benefit from patent quality signal.
2	Are patent signals for the IPO market? Evidence for an empirical analysis of the US and the European software industry	Diego, Useche. (2012).	IPO firms in US-EU	High-tech sector: Software industry	C-tests and standard checks for exogeneity and instrument weakness - First stage regressions	- Patenting behavior impacts investor perception in IPO market - Higher impact of patent metrics as a signal in Europe
3	Patent Commercialization Strategy and IPO Underpricing: Evidence from the US Semiconductor Industry	S, Morricone., F, Munari., R, Oriani. (2010).	US IPO firms	High-tech Semiconductor industry.	OLS regression model	Patent commercialization strategy affects IPO underpricing - Licensing-based strategy increases underpricing at IPO

4	Innovation, Appropriability and the underpricing of Initial Public Offering	Michael, B., Heeley., Sharon, F., Matusik., Neelam, Jain. (2009).	US IPO firms	Low-tech: manufacturing industry	OLS regression model	patents reduce information asymmetries in industries where the link between patents and inventive returns is transparent, thereby reducing under pricing.
5	Patenting and the early stage high-technology investor: evidence from the field	Julia, A., Smith., Renzo, Cordina. (2015).	UK and European venture capital	High-tech industries	Fieldwork methods	Patenting has an impact on the level of investment in high-technology firms. - The existence of patenting is linked to the level of investment made.
6	Commercialization Strategy and IPO Underpricing	Serena, Morricone., Federico, Munari., Raffaele, Oriani., Gaétan, de, Rassenfosse. (2017).	US IPO companies	High-tech: semiconductor industry	Limited-information maximum likelihood (LIML) estimator	patents act as a positive quality signal for investors in the presence of revenues generated by a licensing-based strategy in an IPO.
7	The impact of patent activities on Stock Dynamics in the High-tech Sector	Constantine, Alexander, Vitt., Hui, Xiong. (2015)	Companies in NASDAQ	High-tech: technology sector	multivariate linear regression	patent activities of high-tech companies have significant their stock price movement.
8	Small firm, big patent? Estimating patent value using data on Israeli start-up's financing rounds	Greenberg (2013)	Isreal start-up	High-tech: Semiconductors, Communications, Life sciences, Cleantech, IT and	OLS regression	-Patent applications positively impact start-up valuations - Granting of patents enhances investors' perception of firm value.

				enterprise software, and the internet		
9	Picking winers or building them? Alliance, intellectual, human capital as selection criteria in venture financing and performance of biotechnology startups	Baum and Silverman (2004)	Canada startups	Biotechnology	Log-linear growth model	Startups' alliance, intellectual, and human capital characteristics affect performance.
10	The Impact of Innovation on IPO Short-term Performance – Evidence from the Chinese Markets	Lu, (Jolly), Zhou., Lu, (Jolly), Zhou., Mehdi, Sadeghi. (2019).	Chinese start up	Broad range of industries	OLS regression	More patents before IPO result in shorter honeymoon period - R&D spending leads to greater IPO underpricing

5.2.2. High-Tech vs. Low-Tech: Navigating Information Asymmetry in IPOs

The classification of industries serves as a bedrock for economic research and business analysis, offering a framework to categorize enterprises into high- and low-tech sectors based on their underlying technological foundations. This system provides valuable insights for business managers and academic researchers alike, facilitating the monitoring of economic trends, the identification of market competitors, performance benchmarking, and the construction of sector-specific indices (Phillips & Ormsby, 2016).

High-tech companies, driven by an unrelenting commitment to innovation, amass a significant array of intangible assets, including patents, extensive research and development endeavors, and various forms of intellectual property. However, the inherently abstract nature of these assets presents a formidable challenge for investors, who grapple with the intricacies of evaluating and comprehending their significance (Zingales, 2000). High-tech enterprises are often prolific patent holders, a testament to their dedication to innovation. Nevertheless, the sheer quantity of patents introduces a conundrum – discerning the quality and market relevance of each patent becomes a complex endeavor, fostering an environment of information asymmetry that perplexes investors (Munari & Toschi, 2015).

In stark contrast, low-tech counterparts lean heavily on physical assets, which form the cornerstone of their daily operations and expansion strategies (Zingales, 2000). In the realm of patents, low-tech firms typically maintain a leaner portfolio, simplifying the evaluation process for investors. This dichotomy in asset composition not only mitigates information asymmetry but may also hint at lower levels of innovation within low-tech enterprises.

High-tech companies inhabit a dynamic landscape characterized by the rapid evolution of science and technology. To sustain their competitive edge, they must engage in continuous innovation, introducing groundbreaking products and services to an ever-evolving marketplace (Buenechea-Elberdin et al., 2018; De Carolis, 2010). Innovation projects in this high-stakes environment often span protracted timelines and remain shrouded in uncertainty, amplifying the risks for prospective investors (Brown et al., 2012). An unmistakable feature of high-tech firms is the intricacy of their patent portfolios. As they relentlessly push the boundaries of innovation, their patent holdings accumulate, culminating in portfolios that are multifaceted and complex (Guiso, 1998).

The intricacy of high-tech patents often surpasses the comprehension of non-expert investors, introducing an additional layer of information asymmetry. Investors, particularly those without specialized knowledge in the specific technical domain, grapple with the herculean task of accurately evaluating the significance and market relevance of high-tech patents (Guiso, 1998). This complexity inherent in high-tech innovation projects, coupled with the prolonged timelines fraught with uncertainty, creates an environment where risk is magnified. Investors considering financing such ventures face multifarious challenges. The high degree of unpredictability associated with the realization of returns from innovation projects further elevates the perceived risk. Consequently, investing in high-tech firms becomes a significantly riskier proposition, as evidenced by previous research (Brown et al., 2012; Guiso, 1998).

The paradox of high-tech firms resides in their relentless pursuit of innovation within the opacity of their patent portfolios. While they endeavor to redefine the boundaries of science and technology, the very complexity of their innovations and patent holdings often obscures their true potential from external investors. This opacity contributes to information asymmetry, making it difficult for investors to discern the value and significance of the intellectual property held by high-tech companies.

In contrast, low-tech enterprises operate in a relatively stable and less tumultuous business environment. Their reliance on established technologies and products introduces an element of predictability that stands in sharp contrast to the high-tech landscape. Consequently, their innovation projects tend to be simpler, more focused, and associated with reduced inherent risks (Buenechea-Elberdin et al., 2018; De Carolis, 2010).

High-tech firms navigate a landscape marked by intricate knowledge-sharing mechanisms, complex interdependencies among various components, and a reliance on tacit communication, distinguishing them from their low-tech counterparts (Schilling & Shankar, 2019). This distinction is particularly evident in their approach to innovation. Low-tech ventures often pursue simpler, more focused innovations, resulting in projects with straightforward objectives. In contrast, the competitive nature of high-tech industries often compels firms to embark on diversified innovation endeavors aimed at enhancing the competitiveness of a single product.

This multiplicity of innovation pathways undertaken by high-tech companies contributes to the complexity of their patent portfolios, rendering them more challenging for investors to fully comprehend. While patents undoubtedly serve as valuable signals of a firm's innovation activity, their efficacy as signals is tempered by the intricate nature of high-tech patents. Consequently, high-tech firms may find themselves undervalued due to the inherent difficulties investors encounter when attempting to decipher the information embedded in their patents. This challenge becomes even more pronounced when a company's innovation spans a wide spectrum of knowledge domains (Levin et al., 1987)

The elevated risk associated with high-tech ventures can be attributed to the interdependencies that exist among various components within their innovation projects. Unlike low-tech companies, whose innovation pursuits tend to be more self-contained, high-tech firms often rely on a network of interconnected elements. The success of an innovation project hinges on the harmonious functioning of these components, introducing an added layer of risk. Consequently, when investors consider high-tech ventures with numerous risky projects and deferred positive cash flows, they tend to exercise caution, particularly in the pre-IPO phase (Levin et al., 1987).

In addition to these complexities, high-tech industries are characterized by the rapid pace of technological advancement. Patents originating from high-tech firms run the risk of quickly becoming obsolete as newer technologies emerge, casting uncertainty over their long-term value. Investors interested in high-tech IPOs must remain vigilant and continuously update their understanding of technological trends to accurately assess the relevance of patents within this dynamic landscape.

On the other hand, low-tech industries often feature technologies that are more stable and enduring. Patents in these sectors may maintain their relevance over more extended periods, reducing the risk of obsolescence. This stability contributes to a lower level of information asymmetry, as investors can have greater confidence in the long-term value of patents associated with low-tech ventures.

Based on the aforementioned arguments and the distinctive characteristics of high-tech and low-tech firms, it is reasonable to assume that the information asymmetry associated with innovation activities, as manifested through patents, is more pronounced among high-tech companies compared to their low-tech counterparts. This heightened information asymmetry can lead to investor unease and uncertainty, particularly when assessing the potential of high-tech firms entering the stock market to raise capital successfully. This stark dichotomy between high-tech and low-tech companies, encompassing innovation complexity, risk profiles, and patent portfolio opaqueness, underscores the fundamental disparities in how investors perceive and approach these firms. These inherent differences become even more pertinent when considering their respective IPO performances, necessitating a comprehensive exploration of their impact on IPO outcomes. In essence, the core question at the heart of this study revolves around whether high-tech companies, when making their initial public offerings, encounter greater challenges in securing capital compared to their low-tech counterparts. While existing literature has explored various disparities between high-tech and low-tech firms, including differences in motivation, issuance strategies, and long-term performance outcomes, there remains a significant gap in our understanding of how these distinctions translate into divergent IPO success rates.

Prior research on IPOs has often adopted a one-size-fits-all approach, treating all IPOs as a homogeneous group or focusing solely on specific industries like biotechnology, semiconductors, software, or the internet. This approach has overlooked the nuances and idiosyncrasies of high-tech and low-tech firms, neglecting their unique characteristics and their potential impact on IPO performance. To address this gap and contribute fresh insights to the fields of entrepreneurship and innovation, this study centers on Japanese IPOs. It seeks to shed light on how the signaling effect of patents diverges between high-tech and low-tech IPOs in the Japanese context. As part of this endeavor, we propose the following hypothesis:

***Hypothesis 1**: All other conditions being equal, the patents held by high-tech firms before their IPOs have relatively weaker signaling effects on IPO performance compared to those of low-tech firms.*

This hypothesis serves as a critical focal point for our research, as we aim to empirically investigate the extent to which patent signaling influences the outcomes of IPOs in the high-tech and low-tech sectors within Japan. By testing this hypothesis, we seek to unveil the intricate relationship between technology intensity, patent signaling, and IPO performance, ultimately enhancing our understanding of the intersection between innovation, finance, and corporate success in the context of initial public offerings.

The conceptual framework of the study is demonstrated in **Figure 5.1.**

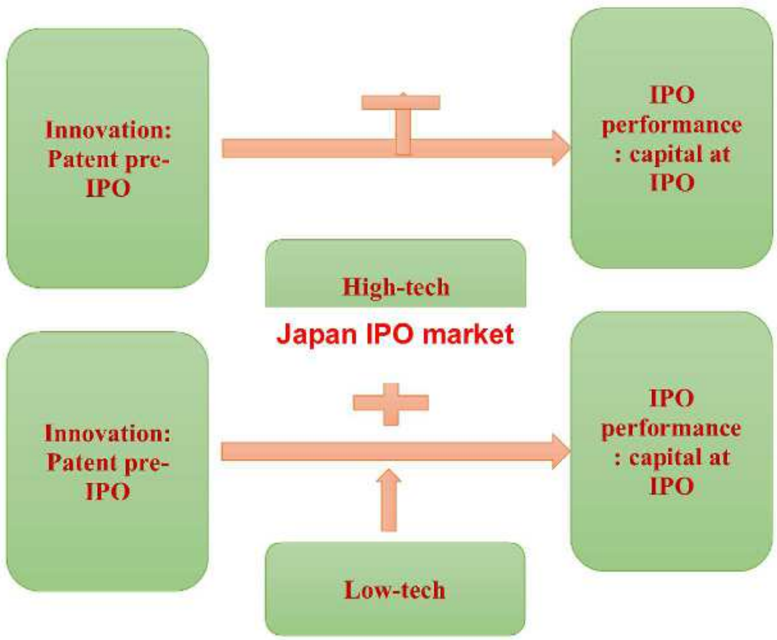


Figure 0.1 Patent signal High-tech vs Low-tech

5.3. Data Collection and Methodology

5.3.1. Data:

We built a dataset to identify IPO deals between 1 January 2000 and 31 December 2015 for all firms—including manufacturing and non-manufacturing firms— in Japan listed in the Japan Exchange Group (JPX) database. The sample time is chosen in consideration of market stability, the regulatory framework for signaling, and transparency. Patenting data, which are the main source of data collection, were hand-collected from the Japan Platform for Patent Information (JplatPat). Considering that only companies with active innovation output are our target, we excluded firms with no patent application at IPO; also, firms pursuing "trade-secret" are removed since this is beyond the scope of our current work. IPO data including Proceed, Underwriter, and Stock Market are obtained from Thomson Reuters Eikon. The FinancialQuest database was used to extract pre-IPO performance characteristics, namely number of employees, debt-to-equity ratio, and firm age. Two distinct classifications of high-tech and low-tech firms used in our analysis are the international standard industrial classification proposed by OECD for main analysis and The Refinitiv industrial classification proposed by Thomson Reuters for robustness checks. Considering only companies with available information and dropping outlier data, our sample is made up of 338 newly listed Japanese IPO firms, which include 242 high-tech firms and 96 low-tech firms (according to OECD classification).

5.3.2. Variables:

- ***Dependent variable:***

IPO performance: To measure the success for an IPO, the key dependent variable in our research is defined as the amount of money raised by a firm via an IPO, which we refer to as Proceed (PROCEED). The proceeds are computed by multiplying the number of total issues by the firm's issue price on the IPO day. The benefit of concentrating on proceeds is that it is a key indicator of how the market views a company at the time of its first offering.

- ***Independent Variables:***

Patent Stock: To measure for the patenting of a firm before IPO, we use the total patent application at the date of the IPO. We followed (Useche, 2014) and (SERENA Morricone et al., 2010) to create variables named PAT4 and PAT5 that measure the patents filed by the company in the last four years prior to the IPO and the patents filed by the company in the last four years prior to the IPO, respectively. Patents grant 20 years of protection from filing. Old patents may not represent the company's current innovation performance (Heeley et al., 2007). Additionally, recent patent applications reveal organizations' innovative capability at the time of an IPO (Useche, 2014). Only recent patents will include up-to-date information on commercial innovation value; we decided to use both PAT4 and PAT5 to conduct the same regression for our key independent variables.

- ***Control Variables:***

Firm Size: Larger firms (in terms of size) generally perform better than smaller firms (Ritter & Welch, 2002). We calculate the firm size (SIZE) as the natural logarithm of the total number of employees in the year preceding IPO (Welbourne & Andrews, 1996).

Firm Age: In general, older businesses do better than newer ones (Ritter, 1998). The natural logarithm of the interval between the year of the IPO and the year of the business's founding is used to determine the firm age (AGE).

Financial Ratio: To measure the stability of a firm, we choose the leverage ratio debt-to-equity ratio in the year preceding the IPO (D/E RATIO) (Herawati, 2017). The more stable and less risky the financial structure, the smaller this ratio. We use a natural log transformation of D/ERATIO to account for the data's skewedness.

High-tech Dummy: To distinguish high-tech from traditional firms we have constructed two dummy variables using information drawn from international standard industrial classification conducted by the OECD (Galindo-Rueda & Verger, 2016). This categorizes industries by their R&D intensity (See **Appendix 1** for the industrial classification). The sector is high-tech if the R&D intensity is above 5%, and low-tech if below 5%. The HILO_DUMMY variable is assessed as "1" for high-tech IPOs and "0" for low-tech IPOs.

In the robustness check, we substitute the OECD industrial classification with the new industrial classification proposed by Thomson Reuter in order to form a new set of high-tech and low-tech enterprises. Thomson Reuter classification is a worldwide market-oriented Industrial categorization sector designed for use by investment bankers, research analysts, and fund managers to compare and assess firms with comparable market characteristics. With the new industrial classification, we also assed "1" for high-tech IPOs and "0" for low-tech IPO.

Underwriter Reputation Dummy: High-ranking underwriters signal a high-quality offering, which may improve the success of an IPO (Brau & Fawcett, 2006; Loughran & Ritter, 2004). To measure the effect of underwriter reputation on IPO performance, we include UW_DUMMY to our model. UW_DUMMY variable is assessed as "1" if the underwriter belongs to one of top five Japanese underwriters: Mizuho, Nomura, Daiwa, Mitsubishi UFJ Morgan Stanley, or SMBC Nikko according to Statista and "0" otherwise.

Stock Exchange Dummy: Decisions made by investors may be influenced by the stock exchanges on which the IPO firm's shares are listed (Corwin & Harris, 2001). We add the STOCK_DUMMY variable to our model to represent the exchange in which the IPO firm is listed. The STOCK_DUMMY recorded a value of 1 for firm that is listed on the Tokyo Stock Market (TSE), the largest stock exchange in Japan, and a value of 0 for all other companies.

Venture Capitalist Backing Dummy: We also accounted for the potential implications of venture capital backing (VC_DUMMY) (Certo et al., 2001)This factor has been demonstrated to have an impact on how well an IPO business can raise money (Brav & Gompers, 2003; Gulati & Higgins, 2003). We count a value of 1 for IPOs backed by venture capitalists and 0 otherwise.

Year Dummy: To account for IPO time-specific tendencies, we additionally append the whole set of year dummies as "Year2000" through "Year2015."

5.3.3. Econometric Model:

We investigated the question of whether differences in the degree of information asymmetry between high-and low-tech firms are caused by difficulties in interpreting information relating to patents and whether this moderates the effect of the patent on IPO performance. We then generated a second model in which an interaction term between Patent Stock and HILO_DUMMY. We estimated the following OLS equation in **Equation 1** to test Hypothesis 2:

Equation 1:

$$\mathrm{PROCEED}_i = \alpha_0 + \alpha_1 \mathrm{PATENT\_STOCK}_i + \alpha_2 \mathrm{PATENT\_STOCK}_i * \mathrm{HILO\_DUMMY}_i + \alpha_3 \mathrm{CONTROL\_VARIABLE}_i + \varepsilon_i \quad (1)$$

Where:

- PROCEED: the amount of money that a company may raise on the day of its IPO;
- PATENT_STOCK: Patent application by a firm in the prior to the IPO. Where PATENT_STOCK is equal to PAT4 and PAT5 respectively;
- HILO_DUMMY: Dummy variable is assessed as 1 for high-tech IPOs and 0 for low-tech IPOs; CONTROL_VARIABLES: set of control variables,
- ε: Statistical errors.

The hypothesis argues that information asymmetry associated with patent evaluation is more pronounced for high-tech firms than for low-tech firms, causing the IPO performance of high-tech firms to be less successful than their low-tech peers in term of capital raised at IPO, and implying that the coefficient on the interaction term $\mathrm{PATENT\_STOCK}_i * \mathrm{HILO\_DUMMY}_i$ is lower than zero ($\alpha_2 < 0$).

5.4. Result:

5.4.1. Preliminary Analysis:

The descriptive statistics in **Table 5.2** presented offer valuable insights into the differences between high-tech and low-tech firms in various aspects, shedding light on the distinctive characteristics of these two sectors and their behavior in the context of initial public offerings. The full version of preliminary analysis is presented in Appendix 8.

Table 5.2 Descriptive Statistic

Covariate	**High-tech (N=242)**		**Low-tech (N=96)**	
	Mean	**S.D**	**Mean**	**S.D**
PROCCED	5539.635	14215.986	3213.351	5989.836
PAT4	66.752	355.351	29.031	66.911
PAT5	83.219	474.738	33.719	77.750
SIZE	1066.711	3404.823	742.656	2127.505
AGE	24.967	19.745	31.281	21.961
D/E Ratio	2.031	3.142	3.088	5.655
HILO_DUMMY	1.000	0.000	0.000	0.000
UW_DUMMY	0.781	0.414	0.750	0.435
STOCK_DUMMY	0.240	0.428	0.177	0.384
VC_DUMMY	0.351	0.478	0.385	0.489

First, let's examine the differences in the amount of finance collected by firms at IPO (PROCCED). High-tech firms, on average, raise a significantly larger amount at IPO, with an average of approximately 5539.64 million yen, compared to their low-tech counterparts, who raise an average of about 3213.35 million yen. This substantial difference in IPO proceeds highlights the disparity in the financial resources available to these two types of firms when entering the public market. High-tech firms appear to have a distinct advantage in terms of fundraising during their IPOs, which could be attributed to their innovative and potentially high-growth nature.

Next, focusing on patent-related variables, it's evident that high-tech firms exhibit a higher level of patent activity compared to low-tech firms. The number of patent applications before IPO (PAT4 and PAT5) is notably greater in high-tech sectors. High-tech firms file an average of 66.75 patents in the four years prior to IPO and 83.22 patents in the five years prior to IPO, while low-tech firms file fewer patents, with averages of 29.03 and 33.71 patents in the respective timeframes. This disparity underscores the emphasis on innovation and intellectual property within the high-tech sector. These firms invest significantly in protecting their technological advancements, which could be seen as a strategy to signal their commitment to innovation and their competitive advantage.

Another dimension to consider is the size of the firms (SIZE) before their IPOs. High-tech firms tend to be larger, with an average of 1066.71 employees, compared to low-tech firms, which have an average of 742.65 employees. This divergence in size may be indicative of the nature of their operations. High-tech companies, often involved in cutting-edge technology, may require larger teams to develop and commercialize their innovations. This aligns with their higher patent activity, as more resources are likely dedicated to research and development efforts.

Furthermore, the age of the firms (AGE) before IPO differs significantly between the two sectors. Low-tech firms have a longer operating history, with an average age of 31.28 years, whereas high-tech firms have a shorter average age of 19.74 years. This discrepancy suggests that low-tech companies tend to have a more extended period of development and establishment before deciding to go public. In contrast, high-tech firms, driven by the rapid pace of technological advancements, may seek IPO opportunities at an earlier stage in their development.

Regarding financial leverage, as indicated by the debt-to-equity ratio (D/E Ratio), low-tech IPOs have a higher average ratio of 3.09, while high-tech IPOs exhibit a lower average ratio of 2.03. This variation is in line with expectations, as capital-intensive businesses like traditional low-tech firms often rely on debt to finance their operations and infrastructure. In contrast, high-tech firms, which often focus on intangible assets and knowledge-based innovations, may have less need for substantial debt financing, resulting in lower debt-to-equity ratios.

In conclusion, the descriptive statistics highlight the substantial differences between high-tech and low-tech firms across various dimensions. High-tech firms, with their larger IPO proceeds, higher patent activity, and younger age, appear to be positioned as innovative and high-growth entities. On the other hand, low-tech firms, characterized by larger sizes, longer operating histories, and higher debt-to-equity ratios, seem to have a more established and capital-intensive nature. These differences reflect the unique attributes and strategies of each industry sector, ultimately influencing their behavior in the IPO market.

5.4.2. Main Analysis:

Regression results are presented in **Table 5.3** using two Panels. Panel I report regression results where PAT4 is used as an independent variable. Panel II shows results on the usage of PAT5 as an independent variable. The full result of the regression is presented in Appendix 9.

Table 5.3 Main result analysis

	Panel I STOCK_PATENT = PAT4	Panel II STOCK_PATENT=PAT5
	Model 1	Model 2
Intercept	5.6705*** 0.394	5.6627*** 0.393
PAT4	0.0040** 0.002	
PAT4*HILO_DUMMY	-0.0035* 0.002	
PAT5		0.0035*** 0.002
PAT5*HILO_DUMMY		-0.0032* 0.002
SIZE	0.3847*** 0.058	0.3884*** 0.058
AGE	-0.3442*** 0.0093	-0.3496*** 0.092
D/E RATIO	-0.0557 0.062	-0.0548 0.062
HILO_DUMMY	0.4288*** 0.162	0.4364*** 0.162
UW_DUMMY	0.2780* 0.165	0.2759* 0.165
STOCK_DUMMY	0.4285** 0.195	0.4347** 0.195
VC_DUMMY	-0.1611 0.146	-0.1588 0.146
YEAR_DUMMY	Yes	Yes
Adj_R_square	0.278	0.278
F-STATISTIC	15.44	15.40
PROB(F-STATISTIC)	5.29e-21	6.09e-21
Observation	338	338

Note: Value are regression coefficients with standard errors in parentheses; *p<0.1, **p<0.05, ***p<0.01.

The analysis conducted to test ***Hypothesis 1,*** which examines whether the industry moderates the effect of patents on IPO performance, yielded significant results, as presented in two panels: Model 1 of Panel I and Model 2 of Panel II.

In Model 1 of Panel I, it's crucial to note the significant coefficients for both PAT4 and the interaction term PAT4*high-tech dummy variable. These coefficients provide valuable insights into the relationship between patent stock and IPO performance in high-tech and low-tech sectors. First, the coefficient for PAT4 indicates that the patent stock of high-tech IPOs is significantly negatively associated at the 10% significance level (-0.0035*) with the firm's total proceeds at IPO. This means that, for high-tech firms, an increase in the number of patents filed in the four years prior to IPO is linked to a decrease in the total proceeds raised at the IPO. This negative association suggests that, in high-tech industries, the additional effect of patent applications before IPO may not significantly enhance IPO performance in terms of fundraising.

On the other hand, the coefficient for the interaction term PAT4*high-tech dummy variable is also significant. This interaction term signifies that the effect of patent stock on IPO performance varies between high-tech and low-tech sectors. Specifically, for low-tech IPOs, the association between patent stock and total proceeds at IPO is significantly positive. In other words, in low-tech industries, a higher number of patents filed in the four years before IPO is associated with an increase in the total proceeds raised at the IPO.

Model 2 of Panel II reinforces the findings observed in Model 1 of Panel I. In Model 2 of Panel II, the interaction term PAT5*HILO_DUMMY also demonstrates a consistent result, with a negative and significant coefficient at the 10% significance level (-0.0032*). This indicates that the moderating effect of the industry (high-tech vs. low-tech) on the relationship between patent stock and IPO performance remains consistent when considering patent applications filed in the five years prior to IPO.

Overall, the results strongly support ***Hypothesis 1***, indicating that the industry type indeed moderates the effect of patents on IPO performance. The findings suggest that, in high-tech industries, the additional benefit derived from an increased number of patent applications before IPO is relatively low and may even have a negative impact on IPO proceeds. This phenomenon could be attributed to the higher disclosure of competitive information risk associated with patent applications in high-tech firms. In contrast, low-tech firms appear to benefit positively from a higher number of patent applications in terms of their IPO performance.

In summary, the research findings emphasize the importance of considering the industry context when evaluating the impact of patent activity on IPO performance. The results suggest that while patents may play a crucial role in signaling and reducing information asymmetry in IPOs, their effects can vary significantly depending on whether the firm operates in a high-tech or low-tech sector.

The control variable slope coefficients are broadly consistent with past studies. At the 1% significance level, all models show a positive relationship between the size of the firm and Total Proceed. It indicates that larger companies have higher IPO valuations, presumably because investors see bigger IPOs as less risky than smaller peers since they have a greater chance of successfully capitalizing on their public listing (Chahine & Goergen, 2013; Gu, 2003; Useche, 2014). The Total Proceed is surprisingly negatively associated to the company's age, opposite to our expectation. Our possible explanation is that a firm's age is associated with ex ante uncertainty. There is a negative association between the age of a business and its total proceeds since short-term returns are greater for younger companies (which are associated with high uncertainty). This finding is consistent with (Ahmad-Zaluki & Kect, 2012)'s study on different IPO markets. The impact of a business's financial stability, as evaluated by its debt-to-equity ratio, is positive but not statistically significant, giving little evidence for the association between a firm's stability and its IPO success. Consistent with (Carter et al., 1998) and (An & Chan, 2008), we find that underwriter reputation is significantly positively associated with a successful IPO outcome. This study found Stock Dummy to be significant and positively affect IPO performance at a p-value of 0.010. The Tokyo Stock Exchange sector typically provides a trading market for businesses whose most well-known, established firms will be listed. Investors frequently invest substantial quantities of money in these firms because they believe they will continue to perform well in the future. The effect of venture capital is not significant; thus, we can conclude that a Japanese company being backed by venture capital has no impact on its listing success.

5.5. Robustness Test:

The use of the OECD industrial categorization has long been a cornerstone framework in research for identifying and segmenting companies into high-tech and low-tech categories. This approach has been widely adopted in previous empirical research studies (Buenechea-Elberdin et al., 2017; Cozza et al., 2012; Mendonça, 2009; Vaidya et al., 2007). However, recent developments in research have raised questions about the validity and reliability of using R&D intensity measures as the sole technique for sample selection and categorization. One major concern lies in the complex and intertwined relationship between R&D activities and patenting. These two factors, R&D and patenting, exhibit a highly causal and interconnected relationship. As such, it becomes challenging to disentangle their individual contributions to the signaling effect. It is conceivable to argue that, when controlling for the signaling effect of R&D, patents may have limited signaling value per se. This concern is especially relevant when considering that the correlation between R&D intensity and patenting may be relatively low within the sample under study.

To address these concerns and enhance the robustness of the analysis, a robustness check was conducted. In this check, the traditional OECD industrial classification was substituted with a new industrial classification proposed by Thomson Reuters. This alternative classification system, developed for global market-oriented purposes, is designed to assist investment bankers, research analysts, and fund managers in comparing and assessing firms based on comparable market characteristics. What sets the Thomson Reuters classification apart is its comprehensive approach to categorizing firms. Instead of relying solely on R&D intensity as a primary indicator, this classification method takes into account a wide array of indicators and criteria. These criteria include a firm's business description, utilization of the firm's products, assessment of its assets and profitability, analysis of its business strategy, evaluation of market perception, and more. By considering multiple dimensions of a firm's characteristics and operations, the Thomson Reuters classification aims to differentiate technological firms from conventional businesses in a more nuanced and holistic manner. This shift in classification methodology seeks to provide a more accurate and nuanced representation of the technological orientation of firms, ultimately contributing to a more robust analysis of the relationship between patents and IPO performance.

Table 5.4 is a summary of the robustness test results for our hypotheses under the new categorization of high-tech and low-tech. Regression findings using PAT4 as an independent variable are shown in Panel I. Results on the use of PAT5 as an independent variable are shown in Panel II. The full result of regression is presented in **Appendix 10.**

Table 5.4 Results of Robustness Check

	Panel I STOCK_PATENT= PAT4	Panel II STOCK_PATENT= PAT5
	Model 1	**Model 2**
Intercept	5.6265*** 0.406	5.6253*** 0.406
PAT4	0.0016*** 0.001	
PAT4*HILO_DUMMY	-0.0013** 0.001	
PAT5		0.0014*** 0.000
PAT5*HILO_DUMMY		-0.0012** 0.000
SIZE	0.3640*** 0.058	0.3652*** 0.058
AGE	-0.2842*** 0.096	-0.2884*** 0.096
D/E RATIO	-0.0614 0.061	-0.0595 0.061
HILO_DUMMY	0.2085*** 0.077	0.2132*** 0.076
UW_DUMMY	0.3146* 0.165	0.3132* 0.196
STOCK_DUMMY	0.4818** 0.192	0.4891** 0.191
VC_DUMMY	-0.2084 0.147	-0.2067 0.147
YEAR_DUMMY	Yes	Yes
Adj_R_square	0.283	0.284
F-STATISTIC	15.79	15.88
PROB(F-STATISTIC)	1.87e-21	1.42e-21
Observation	338	338

Note: Value are regression coefficients with standard errors in parentheses; *p<0.1, **p<0.05, ***p<0.01.

The regression results presented in Panel I and Panel II provide valuable insights into the relationship between patenting activities and IPO performance, while also considering the moderating effect of industry type (high-tech vs. low-tech). These results help us evaluate Hypothesis 1, which posits that the industry moderates the effect of patents on IPO performance.

In Model 1 of Panel I, the interaction term PAT4*HILO_DUMMY has a negative coefficient of -0.0013, also significant at 10%, indicating that the effect of patent stock on IPO proceeds is moderated by the industry type. Specifically, in high-tech industries (HILO_DUMMY = 1), the increase in patent stock has a negative impact on IPO proceeds whereas Patent stock of low-tech IPOs is significantly positively associated with a firm's total proceeds at IPO. The results in Model 2 of Panel II also show a consistent result with Model 1 in Panel I. PAT5 has a positive coefficient of 0.0014 at 1%, indicating that an increase in patent stock is associated with higher IPO proceeds. However, the interaction term PAT5*HILO_DUMMY has a negative coefficient of -0.0012 at 10%, signifying that in high-tech industries, the effect of patent stock on IPO proceeds is negative.

The robustness check, which substitutes the industrial classification with the Thomson Reuters classification, reaffirms the findings. The interaction terms (PAT4*HILO_DUMMY and PAT5*HILO_DUMMY) consistently exhibit negative and significant coefficients, supporting the conclusion that in high-tech industries, patents before IPO have relatively weaker signaling effects on IPO performance.

In summary, the results strongly support Hypothesis 1. The findings suggest that the relationship between patenting activities and IPO performance is indeed moderated by the industry type. While patents positively influence IPO proceeds, this effect is significantly weaker in high-tech industries. Therefore, for Japanese high-tech firms, patents filed before IPO appear to have relatively weaker signaling effects on their IPO performance compared to their low-tech counterparts. These results provide valuable insights into the dynamics of IPOs in different industry contexts.

5.6. Summary

This study is dedicated to investigating the industry-specific signaling impact of patents within the context of IPOs, with a specific focus on Japanese IPO cases. Notably, the research uncovers a fascinating disparity between low-tech and high-tech companies concerning the benefits derived from patent signals. This discovery accentuates the nuanced effects of patents on firms' success, underscoring that the signaling power of patents isn't universally consistent across all industries. Furthermore, this study underscores the underexplored significance of low-tech industries within the realm of IPO research. By delving into the dynamics and implications of patent signaling within this particular context, the research expands our understanding of IPO mechanisms and the role of patents. It also underscores a crucial aspect: investor preferences. It becomes evident that low-tech enterprises possess attributes that investors find appealing, such as innovation portfolios that are easier to comprehend and substantial physical assets. These characteristics align more favorably with investor inclinations, and the study sheds light on how these elements contribute to the success of low-tech firms in the IPO landscape. For high-tech firms, the study offers pertinent practical implications. It advises caution in over-reliance on patents as the sole driver of IPO success. Instead, it suggests proactive strategies to alleviate the information asymmetry often associated with the disclosure of R&D and patent activities. These strategies encompass providing detailed insights into future projects and seeking capital infusion during the IPO process. In essence, the research provides a wealth of insights that can guide both low-tech and high-tech firms in optimizing their approaches to IPOs within the unique context of patent signaling in Japan.

Chapter 6: Conclusion

In the dynamic global business landscape, finance and innovation are recognized as two essential pillars driving corporate success, with both being crucial for a company's long-term sustainability. This requires a harmonious blend of sound financial management and a culture that promotes innovation. Research in the field exploring the relationship between a firm's finance and innovation is burgeoning and provides valuable insights into the factors influencing organizational success. Traditionally, empirical studies have often assumed that financial support drives innovation; however, alternative perspectives propose the reverse causation hypothesis, suggesting that innovation can enhance financial performance. The current corporate management research often takes a segmented approach, focusing on either how innovation signals affect financial performance or how financial decisions influence innovation performance, akin to examining isolated puzzle pieces rather than the entire picture. Our study successfully asserts that finance and innovation are mutually interdependent and mutually influencing. We explore both dimensions by investigating how financial resources stimulate innovation and how innovation, primarily represented by patents, can attract investors and secure financial support. Focusing on Japanese corporations, our research offers a unique perspective due to Japan's diverse business landscape, strong patent system, and commitment to innovation. Japan's risk-averse market and intense global competition underscore the critical role of innovation, with patents serving as signals for economic growth. In summary, our research provides a comprehensive examination of the interplay between finance and innovation in Japanese corporations, offering nuanced insights with relevance for businesses, policymakers, and scholars worldwide.

6.1. Chapter III: Financial sources and firm's innovation outputs: analysis of JASDAQ market

This study examines financial sources, structure and factors that can determine firms' innovation outputs, leveraging on Pecking Order Theory. The primary goal is not to explain how firms strategize their innovative activity, but the drivers to their final innovative results. This study includes seven firms' specific characteristics (R&D intensity, profit distribution, investor optimism, firm size, organizational resources, public listing experience and sector dummy) to control the effect of financial sources on firms' innovation outputs, proxied by patent application, patent publication and patent citation. Evidence, using a sample of 113 manufacturing firms listed in the TSE, is found in relation to how firms' innovation outputs are explained by the different types of financing sources. The propositions of this study seem to be reasonably corroborated with supports by the significant influence of other controlling factors. Nonetheless, a different strength of influence is obtained based on the different type of financial source considered.

Specifically, while both internal financing and external financing sources are important in driving volume and value of innovation outputs, the reliance of firms on self-generated financing conquers. The complementary power of debt financing offers support to the assertion in Pecking Order Theory, concerned on the risk inherited in the different financing means. Relying on financial risk as a basis, hierarchy is adopted from internal financing to external financing source that the priority is given to financial source with lower risk.

This study believes that its empirical findings are important, in view of the diversity of the patent- based data and the different aspect of financing sources used. In particular, their economic interpretation is acceptable and contributes to the confirmation of the hypotheses and the utility of the theory. It is possible to affirm that this study provides an added value in the analysis of firms' innovation outputs, given the small number of studies in the empirical literature which explain innovation simultaneously from the internal to external financing sources. This study contributes to the increasing literature on the use of patents to measure innovation performance by distinguishing the quantity and quality in patent measurement.

Patent documents are a unique data source (Katila, 2000) namely i) patent documents deal with new and useful ideas; ii) patents detail out description of the patented invention and iii) analysis of patents can give early signals of technological change as trend indicators usually appear in patent data before they are reported in trade or technical journals. Thus, patent-based measure should be an integral part of firms' innovation outputs measurement.

Furthermore, the finding of this study displays that firms depending on internal financing source have a more significant effect compared to external financing in driving volume and value of innovation outputs. Following the finding, it is safe to infer that firms should equally prioritize on generating higher cash flow as a primary means in gearing the innovation outputs. From the view of investors, the information of firms' cash flow transmit good information on the innovation output of the firms as innovation provides more ability for the young and innovative firms to grow and sustain in the stock market.

As found in (Dinçer & Karakuş, 2021), innovation outputs have positive long-term effect on the share value of the firms. Investors are prone to participate and commit their capital for long term in firms with good innovation and growth prospect. Thus, focusing on increasing and maintaining an adequate level of cash flow should allow public firms to sustain longer in the stock market. From another view, innovation outputs also help firms to increase the welfare level of the countries as firms, which engage in innovation through the R&D activities, will continuously identify their current problems and lay the groundwork for new products and services. In this way, it contributes not only to the profit of companies, but also meets the rapid changes in the consumers' preferences (Dincer & Karakus, 2021). For these reasons, the study is of special interest.

6.2. Chapter IV: Impact of patent signal on firm's performance at IPO: An empirical analysis of Japanese firms

Our research makes substantial and multifaceted contributions to the existing body of literature focusing on the intricate relationship between patents, innovation, and financial success during the critical phase of initial public offerings IPOs. Its distinctive contributions transcend the conventional boundaries of previous research in several meaningful ways.

First and foremost, it contributes to the literature on innovation and IPO research in several dimensions. This study adds to a greater comprehension of the incentives behind the need to patent in an entrepreneurial organization. Literature has identified patents as property rights to protect a technology, prevent a competitor from entering a similar technologies field, or to grant mutual rights to jointly use the patent for cross-licensing. Our study offers an additional consideration for enterprises considering patenting: a patent can work as a signal to diminish information asymmetries between the company and investors and hence help firm acquire external financial capital. This novel insight highlights the multifaceted role of patents in facilitating financial success.

Additionally, this study broadens the geographical and sectoral scope of inquiry, marking a notable departure from the predominantly Western-focused research landscape. By meticulously examining an extensive dataset encompassing Japanese IPO firms across a diverse spectrum of industries, it effectively bridges a significant gap in the literature. By focusing on the Japanese market, our contribution to the big picture is that, for a risk-averse market like Japan, patents still work perfectly as a signal and reduce information asymmetry. This expansion not only enriches the empirical foundation of patent-signaling studies but also offers fresh insights into how firms across various sectors and regions strategically utilize patents in the context of IPOs.

Using comprehensive data of Japanese companies in all industry sectors, our results show that companies' patenting prior to IPO is credible by leading to better IPO performance measured by the total proceeds at IPO. The results are in line with previous findings and also demonstrate the limitations of prior work in several aspects. For example, (J. Cao & Hsu, 2011) and (Hoenen et al., 2014) found that patenting is a quality signal for venture capital-financing for VC in semiconductors, while (Baum & Silverman, 2004) focus on biotechnology firms, which confirms that all three forms of firm resources—patents, partnerships, and team experience—are positively correlated with the quantity of venture capital funding. Regarding the software venture-backed companies, (Mann & Sager, 2007)found that patents had an impact on overall funding in these businesses. While previous research mainly focuses on patent signaling in venture capital-backed firms and start-ups in certain business areas, such as semiconductors, software, and biotechnology, our research extends its scope to all IPO events for all companies in the market, and it contributes to the innovation literature by demonstrating that patents work as reliable signal to enable entrepreneurs to acquire financial capital from external investors.

Furthermore, this research introduces a temporal dimension to the investigation, delving into the nuanced timing of patent applications concerning IPOs. The findings reveal that patents filed in proximity to the IPO date exert a more pronounced influence on the success of these offerings. This temporal analysis provides valuable insights into how companies strategically deploy patents as signals, particularly as they approach the IPO stage. By shedding light on the dynamics of patent-signaling over time, this study deepens our understanding of the evolving role of patents in shaping investor perceptions and facilitating external finance during IPOs.

Finally, the study employs a comprehensive set of control variables, including firm size, age, financial stability, underwriter reputation, stock exchange, and venture capitalist backing.

This robust analytical framework ensures that the identified relationships are not confounded by extraneous factors, offering a more nuanced and realistic depiction of the factors influencing IPO performance.

In essence, the multifaceted contributions of this research hold significant implications for a wide array of stakeholders, including scholars, practitioners, and policymakers. For scholars, it provides a rich empirical foundation for further exploration of the intricate interplay between patents, innovation, and financial success during pivotal corporate events like IPOs. Practitioners stand to gain valuable insights into how patents can be strategically leveraged to enhance IPO outcomes and secure external financing. Finally, policymakers interested in fostering innovation-driven economic growth and successful IPOs can draw upon the findings of this study to inform their strategies and initiatives, ultimately contributing to broader economic prosperity.

6.3. Chapter V: Does Patent Signaling Vary Contingently Under Technology Intensity? Evidence From High-tech and Low-tech IPO Firms in Japan

Our work in this chapter makes significant contributions to the existing literature on innovation and IPO research by delving into several key dimensions as follow:

The primary contribution of this study lies in its investigation of whether the signaling effect of patents around IPOs varies depending on the technological domain of the industry. The research addresses this question within the context of Japanese IPO cases, offering valuable insights into how patents function as signals (Buenechea-Elberdin et al., 2017; Mendonça, 2009; Vaidya et al., 2007). The findings reveal that, after controlling for the general positive signaling effect of patents, low-tech companies benefit significantly more from patent signals than their high-tech counterparts. This nuanced understanding of industry-specific signaling provides a deeper comprehension of the IPO landscape, highlighting the differential impact of patents on firms' success.

A notable contribution of this study is its emphasis on low-tech industries, which have often been overshadowed in existing IPO literature. While prior research has predominantly focused on high-tech industry groups (Vaidya, Bennett et al. 2007, Mendonça 2009, Cozza, Malerba et al. 2012, Buenechea-Elberdin, Sáenz et al. 2017), this study shines a spotlight on the low-tech sector, uncovering the distinct dynamics and implications of patent signaling within this context. This research encourages further exploration of the signaling effect in low-tech IPOs, urging scholars to delve deeper into the mechanisms of patent signaling specific to these industries.

The study offers insights into investor preferences and risk perceptions based on industry types. Low-tech enterprises, characterized by easier-to-understand innovation portfolios and substantial physical assets (Detragiache et al., 2000; Zingales, 2000) align more favorably with investor preferences. These assets provide tangible security for investors, which is appealing to risk-averse stakeholders. In contrast, high-tech corporations rely on complex innovative projects and knowledge assets. These projects involve lengthy development cycles, unpredictable outcomes, and intangible collateral, which can make investors apprehensive (Brown et al., 2012). The research underscores the need for investors to have a deep understanding of technology, patents, and their commercial potential when assessing high-tech innovation projects.

The study offers practical implications for high-tech firms and their strategic decision-making. Given the complexity of their innovative projects, high-tech companies should exercise caution when relying solely on patents to fuel IPO success. Investors require a profound comprehension of the technology, patents, and their interplay to assess the true value and profitability potential of innovation projects. Consequently, high-tech firms should selectively target specialist investors, such as institutional investors and investment banks, who possess the expertise and risk tolerance needed to evaluate complex innovation portfolios.

To mitigate the information asymmetry associated with R&D and patent activity disclosure, high-tech companies should consider proactive strategies. Providing investors with detailed information about the future of their projects can help stakeholders better assess the associated risks and rewards. Moreover, high-tech firms may explore the option of raising a modest amount of capital during the IPO and conducting secondary offerings once they have established a stronger market presence. This staged approach can help reduce the information gap and bolster investor confidence.

In summary, this study not only advances our understanding of patent signaling in IPOs but also provides actionable insights for firms, particularly high-tech companies, and investors operating within different industry contexts. By shedding light on the industry-specific nuances of patent signaling, this research contributes to a more comprehensive and informed dialogue surrounding innovation, finance, and IPO performance.

6.4. Limitation and Possible Future Research:

This study has identified several limitations that open up promising avenues for future research. Firstly, our sample selection is predominantly focused on the Japanese market, where investors often demonstrate risk aversion in their investment decisions. While this market provided valuable insights, it may not represent a universal standard. The dynamics of patent signaling and its impact on IPO success could differ significantly in diverse contexts, such as emerging markets or highly specialized industries. Therefore, future research should consider the contextual variations in investor behavior and how these factors influence the interplay between patents and IPO outcomes. Researchers should exercise caution when generalizing our findings to these different settings.

Secondly, our study employs a simplified approach in using patent applications as a proxy for innovation, treating all patents uniformly in terms of their value. However, in real-world scenarios, firms' strategic managers often possess private information about core technologies and highly competitive patents, allowing them to assign varying values and prioritize patents based on their expected returns and potential success at an IPO. Future research could explore methods to predict and incorporate the weighted value of each patent, potentially yielding more nuanced and intuitive results.

Thirdly, our analysis revealed that certain control variables, integral to our hypotheses, were measured with less precision due to the qualitative and intangible nature of these variables. This limitation constrained the scope of tests that could be conducted to validate specific hypotheses. Addressing this precision issue in measuring control variables, possibly through more sophisticated measurement techniques or refined indicators, could enhance the robustness of future research.

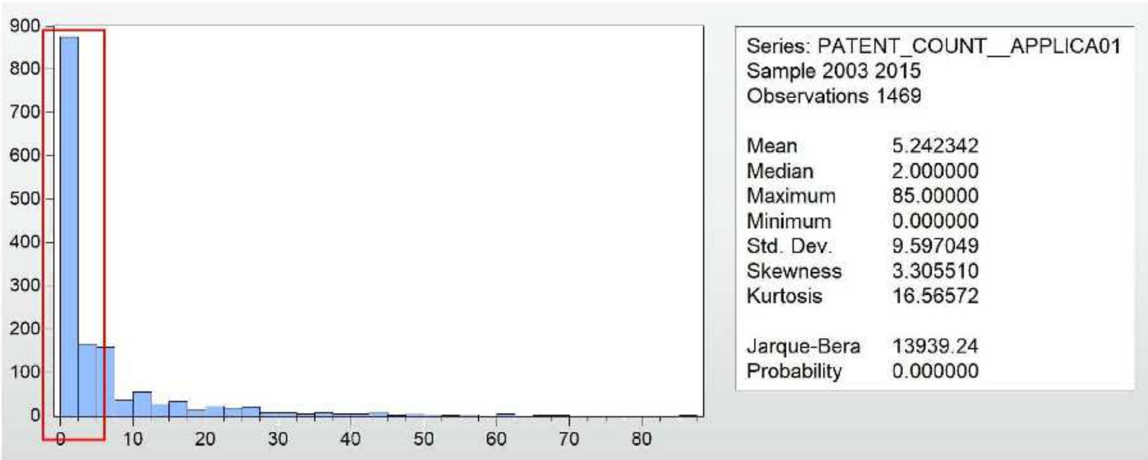
Finally, our study is susceptible to simultaneity bias, an issue that can arise from the inherent relationships between patent applications before an IPO and IPO performance, typically measured by Proceed Money. Future research should actively address potential endogeneity problems stemming from self-selection bias and concurrent interactions between these variables. This could involve more complex modeling techniques and advanced statistical methods to disentangle these relationships and obtain more accurate and reliable results. These avenues for future research hold the promise of expanding our understanding of the intricate connections between patents and financial outcomes in corporate settings.

APPENDIX

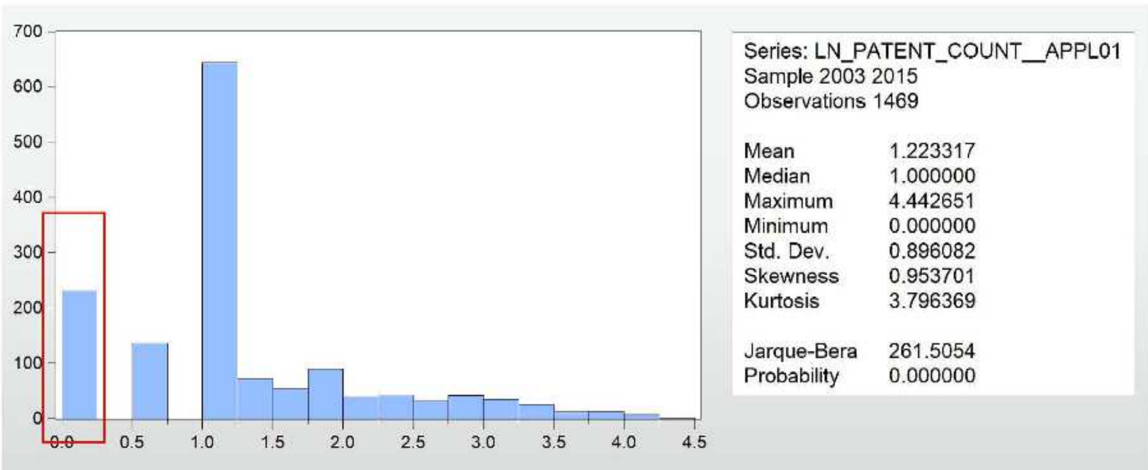
Appendix 1. Descriptive Statistic Result for Chapter 3

DESCRIPTIVE STATISTICS

HISTOGRAM - PATENT COUNT (APPLICATION) (1 YEAR LAGGED)



HISTOGRAM - LOG PATENT COUNT (APPLICATION) (1 YEAR LAGGED)



DESCRIPTIVE STATISTICS (DEPENDENT VARIABLES)

	APP	APP 1	APP 2	APP 3	PPU B	PUB 1	PUB 2	PUB 3	CIT	CIT1	CIT2
Mean	5.36	5.08	4.92	4.81	5.99	5.64	5.33	5.11	4.78	4.92	4.98
Median	2.00	2.00	1.00	1.00	2.00	2.00	2.00	2.00	1.00	1.00	1.00
Maximum	67.00	67.00	67.01	61.00	99.00	73.00	73.00	73.00	85.00	88.00	88.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Std. Dev.	9.17	8.89	8.82	8.64	10.39	9.47	9.07	8.87	9.50	10.00	10.31

DESCRIPTIVE STATISTICS (INDEPENDENT VARIABLES)

	Debt to Equity (DTE)	Ln Cash	R&D to Sales	Dividend Payout	Ln Market Value	Ln Assets	Ln Age Founded	Ln Age after IPO
Mean	1.216290	1257039.	0.027415	2.040572	8752.324	19712157	53.95163	12.33856
Median	0.913100	523000.0	0.011796	1.905000	3722.570	11992061	54.00000	12.00000
Maximum	9.168675	19687000	0.653880	16.82000	216216.6	1.42E+08	128.0000	25.00000
Minimum	-0.990025	0.000000	0.000000	0.000000	286.5900	1239579.	2.000000	0.000000
Std. Dev.	1.138398	2419695.	0.044597	1.645467	17889.19	23603596	20.16360	5.034627
Skewness	2.095924	4.110856	4.634477	1.583534	6.361586	2.772853	0.573768	-0.203493
Kurtosis	9.752456	22.51770	42.94610	9.912694	56.32368	11.08475	4.001980	2.480295
Jarque-Bera	3863.731	27435.53	102858.1	3536.391	183823.8	5879.216	141.9558	26.65225
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000002
Observations	1468	1468	1468	1468	1468	1468	1468	1468

CORRELATION COEFFICIENT MATRIX (INDEPENDENT VARIABLES)

	Debt to Equity (DTE)	Ln Cash	R&D to Sales	Dividend Payout	Ln Market Value	Ln Assets	Ln Age Founded	Ln Age after IPO	Dummy Chemical Sector
DTE	1	-0.130	-0.192	-0.165	-0.193	0.043	-0.106	-0.130	-0.003
Ln Cash	-0.130	1	-0.027	0.045	0.300	0.216	-0.028	0.009	0.092
R&D to Sales	-0.192	-0.027	1	-0.041	0.073	-0.060	-0.139	-0.059	-0.046
Div Payout	-0.165	0.045	-0.041	1	-0.156	0.044	0.082	0.066	0.014
Ln Mkt Value	-0.193	0.300	0.073	-0.156	1	0.716	-0.042	-0.036	0.079
Ln Assets	0.043	0.216	-0.060	0.044	0.716	1	0.110	0.152	0.022
Age Founded	-0.106	-0.028	-0.139	0.082	-0.042	0.110	1	0.418	0.062
Age after IPO	-0.130	0.009	-0.059	0.066	-0.036	0.152	0.418	1	0.000
Dummy Che.	-0.003	0.092	-0.046	0.014	0.079	0.022	0.062	0.000	1

Appendix 2. Main Result for Chapter 3

POISSON REGRESSION RESULTS

1. DV: PATENT COUNT (APPLICATION) – 1 YEAR LAG FROM FINANCIAL STRUCTURE

Current function value: 4.740584						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCOUNT116	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1458			
Method:	MLE	**Df Model:**	9			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2862			
Time:	7:30:55	**Log-Likelihood:**	-6959.2			
converged:	TRUE	**LL-Null:**	-9750.1			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-8.8472	0.245	-36.039	0	-9.328	-8.366
DEBTTOEQUITY	0.1032	0.012	8.459	0	0.079	0.127
LN_CASH_ADJ	0.0423	0.003	12.783	0	0.036	0.049
RD_SALERATIO	4.3541	0.155	28.095	0	4.05	4.658
DIVIDENDPAYOUT	0.0666	0.009	7.763	0	0.05	0.083
LN_MARKETVALUE	0.4132	0.018	23.451	0	0.379	0.448
Ln_TOTALASSETS	0.3465	0.022	16.008	0	0.304	0.389
LN_AGEINCO	0.1505	0.036	4.239	0	0.081	0.22
Ln_AGEAFTERLISTING	-0.1728	0.024	-7.08	0	-0.221	-0.125
DUMMY_CHEMICAL	0.1498	0.027	5.453	0	0.096	0.204

RSS for DEBTTOEQUITY: 69971.92293633896
RSS for LN_CASH_ADJ: 104361.69443533881

2. DV: PATENT COUNT (APPLICATION) – 2 YEAR LAG FROM FINANCIAL STRUCTURE

Optimization terminated successfully.						
Current function value: 4.641218						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCOUNT217	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1458			
Method:	MLE	**Df Model:**	9			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.296			
Time:	7:38:22	**Log-Likelihood:**	-6813.3			
converged:	TRUE	**LL-Null:**	-9678			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-8.9743	0.247	-36.279	0	-9.459	-8.489
DEBTTOEQUITY	0.1174	0.012	9.503	0	0.093	0.142
LN_CASH_ADJ	0.0537	0.004	15.245	0	0.047	0.061
RD_SALERATIO	4.4694	0.154	29.115	0	4.169	4.77
DIVIDENDPAYOUT	0.079	0.009	9.252	0	0.062	0.096
LN_MARKETVALUE	0.4135	0.018	23.207	0	0.379	0.448
Ln_TOTALASSETS	0.339	0.022	15.483	0	0.296	0.382
LN_AGEINCO	0.1342	0.036	3.746	0	0.064	0.204
Ln_AGEAFTERLISTING	-0.1279	0.025	-5.117	0	-0.177	-0.079
DUMMY_CHEMICAL	0.1399	0.028	5.046	0	0.086	0.194

RSS for DEBTTOEQUITY: 70473.34766846558
RSS for LN_CASH_ADJ: 105047.55516746567

3. DV: PATENT COUNT (APPLICATION) – 3 YEARS LAG FROM FINANCIAL STRUCTURE

Current function value: 4.550083						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCOUNT318	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1458			
Method:	MLE	**Df Model:**	9			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.289			
Time:	7:43:19	**Log-Likelihood:**	-6679.5			
converged:	TRUE	**LL-Null:**	-9395			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-9.2198	0.253	-36.408	0	-9.716	-8.723
DEBTTOEQUITY	0.1051	0.013	8.234	0	0.08	0.13
LN_CASH_ADJ	0.0543	0.004	15.133	0	0.047	0.061
RD_SALERATIO	4.5089	0.156	28.981	0	4.204	4.814
DIVIDENDPAYOUT	0.076	0.009	8.743	0	0.059	0.093
LN_MARKETVALUE	0.3805	0.018	20.79	0	0.345	0.416
Ln_TOTALASSETS	0.3735	0.022	16.637	0	0.33	0.418
LN_AGEINCO	0.1315	0.037	3.596	0	0.06	0.203
Ln_AGEAFTERLISTING	-0.1522	0.025	-5.998	0	-0.202	-0.102
DUMMY_CHEMICAL	0.1477	0.028	5.226	0	0.092	0.203

RSS for DEBTTOEQUITY: 63924.348835317796
RSS for LN_CASH_ADJ: 105761.40033431767

4. DV: PATENT COUNT (APPLICATION) – 4 YEARS LAG FROM FINANCIAL STRUCTURE

Current function value: 4.449196						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCOUNT419	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1458			
Method:	MLE	**Df Model:**	9			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2786			
Time:	7:47:21	**Log-Likelihood:**	-6531.4			
converged:	TRUE	**LL-Null:**	-9053.5			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-9.0324	0.261	-34.647	0	-9.543	-8.521
DEBTTOEQUITY	0.1391	0.013	10.931	0	0.114	0.164
LN_CASH_ADJ	0.0656	0.004	16.717	0	0.058	0.073
RD_SALERATIO	4.5729	0.162	28.273	0	4.256	4.89
DIVIDENDPAYOUT	0.0804	0.009	8.955	0	0.063	0.098
LN_MARKETVALUE	0.3887	0.019	20.825	0	0.352	0.425
Ln_TOTALASSETS	0.3455	0.023	15.039	0	0.3	0.391
LN_AGEINCO	0.1512	0.037	4.049	0	0.078	0.224
Ln_AGEAFTERLISTING	-0.2068	0.026	-8.053	0	-0.257	-0.156
DUMMY_CHEMICAL	0.1244	0.029	4.23	0	0.067	0.182

RSS for DEBTTOEQUITY: 53533.33861119247
RSS for LN_CASH_ADJ: 107696.38611019254

POISSON REGRESSION RESULTS

1. **DV: PATENT COUNT (PUBLICATION) – 1 YEAR LAG FROM PATENT APPLICATION**

Current function value: 5.071209						
Iterations 6						
Poisson Regression Results						
Dep. Variable:	PATENTPUB116	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1458			
Method:	MLE	**Df Model:**	9			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2688			
Time:	7:55:29	**Log-Likelihood:**	-7444.5			
converged:	TRUE	**LL-Null:**	-10181			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-8.349	0.235	-35.487	0	-8.81	-7.888
DEBTTOEQUITY	0.1145	0.011	10.082	0	0.092	0.137
LN_CASH_ADJ	0.0365	0.003	11.816	0	0.03	0.043
RD_SALERATIO	4.1111	0.157	26.178	0	3.803	4.419
DIVIDENDPAYOUT	0.0449	0.008	5.351	0	0.028	0.061
LN_MARKETVALUE	0.3797	0.017	22.613	0	0.347	0.413
Ln_TOTALASSETS	0.3616	0.021	17.509	0	0.321	0.402
LN_AGEINCO	0.0867	0.033	2.595	0.009	0.021	0.152
Ln_AGEAFTERLISTING	-0.1819	0.023	-7.819	0	-0.228	-0.136
DUMMY_CHEMICAL	0.1546	0.027	5.814	0	0.102	0.207

RSS for DEBTTOEQUITY: 74357.86815372025
RSS for LN_CASH_ADJ: 98753.46365272033

2. DV: PATENT COUNT (PUBLICATION) – 2 YEARS LAG FROM PATENT APPLICATION

Current function value: 4.866157						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTPUB217	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1458			
Method:	MLE	**Df Model:**	9			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2785			
Time:	8:01:56	**Log-Likelihood:**	-7143.5			
converged:	TRUE	**LL-Null:**	-9900.6			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-8.6147	0.24	-35.879	0	-9.085	-8.144
DEBTTOEQUITY	0.1051	0.012	8.85	0	0.082	0.128
LN_CASH_ADJ	0.0445	0.003	13.654	0	0.038	0.051
RD_SALERATIO	4.274	0.154	27.7	0	3.972	4.576
DIVIDENDPAYOUT	0.0525	0.008	6.204	0	0.036	0.069
LN_MARKETVALUE	0.3752	0.017	21.746	0	0.341	0.409
Ln_TOTALASSETS	0.3669	0.021	17.314	0	0.325	0.408
LN_AGEINCO	0.1017	0.034	2.972	0.003	0.035	0.169
Ln_AGEAFTERLISTING	-0.1726	0.024	-7.24	0	-0.219	-0.126
DUMMY_CHEMICAL	0.1254	0.027	4.617	0	0.072	0.179

RSS for DEBTTOEQUITY: 72534.42248019649
RSS for LN_CASH_ADJ: 100295.89597919643

3. DV: PATENT COUNT (PUBLICATION) – 3 YEARS LAG FROM PATENT APPLICATION

Current function value: 4.849118						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTPUB318	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1458			
Method:	MLE	**Df Model:**	9			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2817			
Time:	8:08:40	**Log-Likelihood:**	-7118.5			
converged:	TRUE	**LL-Null:**	-9909.6			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-8.735	0.242	-36.081	0	-9.21	-8.261
DEBTTOEQUITY	0.1121	0.012	9.288	0	0.088	0.136
LN_CASH_ADJ	0.0475	0.003	14.269	0	0.041	0.054
RD_SALERATIO	4.2416	0.156	27.173	0	3.936	4.548
DIVIDENDPAYOUT	0.0724	0.008	8.659	0	0.056	0.089
LN_MARKETVALUE	0.3904	0.017	22.332	0	0.356	0.425
Ln_TOTALASSETS	0.351	0.021	16.378	0	0.309	0.393
LN_AGEINCO	0.0996	0.035	2.849	0.004	0.031	0.168
Ln_AGEAFTERLISTING	-0.1047	0.025	-4.259	0	-0.153	-0.057
DUMMY_CHEMICAL	0.1267	0.027	4.641	0	0.073	0.18

RSS for DEBTTOEQUITY: 72648.18190690887
RSS for LN_CASH_ADJ: 101334.60340590894

4. DV: PATENT COUNT (PUBLICATION) – 4 YEARS LAG FROM PATENT APPLICATION

Current function value: 4.810484						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTPUB419	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1458			
Method:	MLE	**Df Model:**	9			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2773			
Time:	8:12:43	**Log-Likelihood:**	-7061.8			
converged:	TRUE	**LL-Null:**	-9771.4			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-8.585	0.244	-35.172	0	-9.063	-8.107
DEBTTOEQUITY	0.1066	0.012	8.683	0	0.083	0.131
LN_CASH_ADJ	0.0539	0.003	15.629	0	0.047	0.061
RD_SALERATIO	4.2946	0.155	27.735	0	3.991	4.598
DIVIDENDPAYOUT	0.0557	0.009	6.518	0	0.039	0.072
LN_MARKETVALUE	0.3668	0.018	20.725	0	0.332	0.401
Ln_TOTALASSETS	0.3512	0.022	16.191	0	0.309	0.394
LN_AGEINCO	0.08	0.035	2.276	0.023	0.011	0.149
Ln_AGEAFTERLISTING	-0.0725	0.025	-2.902	0.004	-0.121	-0.024
DUMMY_CHEMICAL	0.1178	0.028	4.276	0	0.064	0.172

RSS for DEBTTOEQUITY: 70070.02515856209
RSS for LN_CASH_ADJ: 100441.17465756196

POISSON REGRESSION RESULTS

1. DV: PATENT COUNT (CITATION) – WITHIN 3 YEARS FROM PATENT PUBLICATION

Current function value: 4.423845						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCITATION514	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1458			
Method:	MLE	**Df Model:**	9			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2917			
Time:	8:19:27	**Log-Likelihood:**	-6494.2			
converged:	TRUE	**LL-Null:**	-9168.6			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-11.8539	0.298	-39.838	0	-12.437	-11.271
DEBTTOEQUITY	0.0486	0.015	3.149	0.002	0.018	0.079
LN_CASH_ADJ	0.0422	0.004	10.533	0	0.034	0.05
RD_SALERATIO	4.8017	0.185	25.932	0	4.439	5.165
DIVIDENDPAYOUT	0.135	0.009	14.528	0	0.117	0.153
LN_MARKETVALUE	0.3901	0.021	18.644	0	0.349	0.431
Ln_TOTALASSETS	0.5765	0.026	22.069	0	0.525	0.628
LN_AGEINCO	0.0862	0.039	2.196	0.028	0.009	0.163
Ln_AGEAFTERLISTING	-0.5671	0.027	-21.294	0	-0.619	-0.515
DUMMY_CHEMICAL	0.2609	0.033	8.021	0	0.197	0.325

RSS for DEBTTOEQUITY: 40276.84732527905
RSS for LN_CASH_ADJ: 129060.06682427923

2. DV: PATENT COUNT (CITATION) – WITHIN 4 YEARS FROM PATENT PUBLICATION

Current function value: 4.247922						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCITATION614	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1458			
Method:	MLE	**Df Model:**	9			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.3038			
Time:	8:24:21	**Log-Likelihood:**	-6235.9			
converged:	TRUE	**LL-Null:**	-8957.2			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-12.3578	0.312	-39.557	0	-12.97	-11.746
DEBTTOEQUITY	0.0546	0.016	3.435	0.001	0.023	0.086
LN_CASH_ADJ	0.0456	0.004	10.618	0	0.037	0.054
RD_SALERATIO	4.6014	0.207	22.221	0	4.196	5.007
DIVIDENDPAYOUT	0.1438	0.01	14.882	0	0.125	0.163
LN_MARKETVALUE	0.4525	0.021	21.123	0	0.411	0.494
Ln_TOTALASSETS	0.563	0.027	20.834	0	0.51	0.616
LN_AGEINCO	0.1719	0.041	4.224	0	0.092	0.252
Ln_AGEAFTERLISTING	-0.7074	0.027	-26.395	0	-0.76	-0.655
DUMMY_CHEMICAL	0.2505	0.034	7.399	0	0.184	0.317

RSS for DEBTTOEQUITY: 36223.60661537705
RSS for LN_CASH_ADJ: 135349.40011437717

3. DV: PATENT COUNT (CITATION) – WITHIN 5 YEARS FROM PATENT PUBLICATION

Current function value: 4.021294						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCITATION714	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1458			
Method:	MLE	**Df Model:**	9			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.3158			
Time:	8:26:42	**Log-Likelihood:**	-5903.3			
converged:	TRUE	**LL-Null:**	-8627.9			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-12.3807	0.328	-37.727	0	-13.024	-11.738
DEBTTOEQUITY	0.1178	0.015	7.703	0	0.088	0.148
LN_CASH_ADJ	0.0539	0.005	11.348	0	0.045	0.063
RD_SALERATIO	4.773	0.218	21.944	0	4.347	5.199
DIVIDENDPAYOUT	0.1539	0.01	15.018	0	0.134	0.174
LN_MARKETVALUE	0.5608	0.022	25.951	0	0.518	0.603
Ln_TOTALASSETS	0.4697	0.028	16.997	0	0.416	0.524
LN_AGEINCO	0.3065	0.043	7.153	0	0.222	0.39
Ln_AGEAFTERLISTING	-0.8066	0.027	-29.577	0	-0.86	-0.753
DUMMY_CHEMICAL	0.2352	0.035	6.646	0	0.166	0.305

RSS for DEBTTOEQUITY: 31992.297093907422
RSS for LN_CASH_ADJ: 142724.42659290737

**Main IV: The Interaction of Debt to Equity Ratio* R&D Expenditure to Sales Ratio AND The Interaction of Ln Cash Flow* R&D Expenditure to Sales Ratio*

1. DV: PATENT COUNT (APPLICATION) – 1 YEAR LAG FROM FINANCIAL STRUCTURE

Current function value: 4.737785						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCOUNT116	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1456			
Method:	MLE	**Df Model:**	11			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2867			
Time:	8:55:51	**Log-Likelihood:**	-6955.1			
converged:	TRUE	**LL-Null:**	-9750.1			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-8.8109	0.246	-35.835	0	-9.293	-8.329
DEBTTOEQUITY	0.0872	0.014	6.3	0	0.06	0.114
RD_SALERATIO	3.0218	0.666	4.537	0	1.716	4.327
DEBTTOEQUITY:RD_SALERATIO	0.583	0.235	2.483	0.013	0.123	1.043
LN_CASH_ADJ	0.0396	0.004	10.788	0	0.032	0.047
LN_CASH_ADJ:RD_SALERATIO	0.0862	0.053	1.633	0.102	-0.017	0.19
DIVIDENDPAYOUT	0.0645	0.009	7.468	0	0.048	0.081
LN_MARKETVALUE	0.4088	0.018	23.094	0	0.374	0.443
Ln_TOTALASSETS	0.3516	0.022	16.19	0	0.309	0.394
LN_AGEINCO	0.1386	0.036	3.871	0	0.068	0.209
Ln_AGEAFTERLISTING	-0.166	0.025	-6.756	0	-0.214	-0.118
DUMMY_CHEMICAL	0.1438	0.028	5.209	0	0.09	0.198

RSS for DEBTTOEQUITY: 70006.3026099201
RSS for LN_CASH_ADJ: 104396.07410892016

2. DV: PATENT COUNT (APPLICATION) – 2 YEARS LAG FROM FINANCIAL STRUCTURE

Current function value: 4.638827						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCOUNT217	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1456			
Method:	MLE	**Df Model:**	11			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2964			
Time:	9:00:10	**Log-Likelihood:**	-6809.8			
converged:	TRUE	**LL-Null:**	-9678			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-8.9521	0.248	-36.123	0	-9.438	-8.466
DEBTTOEQUITY	0.1009	0.014	7.22	0	0.074	0.128
RD_SALERATIO	3.6074	0.671	5.38	0	2.293	4.922
DEBTTOEQUITY:RD_SALERATIO	0.6085	0.233	2.612	0.009	0.152	1.065
LN_CASH_ADJ	0.0522	0.004	13.382	0	0.045	0.06
LN_CASH_ADJ:RD_SALERATIO	0.0442	0.053	0.832	0.405	-0.06	0.148
DIVIDENDPAYOUT	0.0766	0.009	8.901	0	0.06	0.094
LN_MARKETVALUE	0.409	0.018	22.86	0	0.374	0.444
Ln_TOTALASSETS	0.3436	0.022	15.638	0	0.301	0.387
LN_AGEINCO	0.1254	0.036	3.47	0.001	0.055	0.196
Ln_AGEAFTERLISTING	-0.1218	0.025	-4.844	0	-0.171	-0.072
DUMMY_CHEMICAL	0.1333	0.028	4.785	0	0.079	0.188

RSS for DEBTTOEQUITY: 70489.09738337615
RSS for LN_CASH_ADJ: 105063.30488237625

3. DV: PATENT COUNT (APPLICATION) – 3 YEARS LAG FROM FINANCIAL STRUCTURE

Current function value: 4.548605						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCOUNT318	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1456			
Method:	MLE	**Df Model:**	11			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2893			
Time:	9:03:30	**Log-Likelihood:**	-6677.4			
converged:	TRUE	**LL-Null:**	-9395			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-9.235	0.254	-36.346	0	-9.733	-8.737
DEBTTOEQUITY	0.0947	0.014	6.598	0	0.067	0.123
RD_SALERATIO	4.9352	0.606	8.144	0	3.747	6.123
DEBTTOEQUITY:RD_SALERATIO	0.3986	0.237	1.68	0.093	-0.066	0.864
LN_CASH_ADJ	0.0562	0.004	14.079	0	0.048	0.064
LN_CASH_ADJ:RD_SALERATIO	-0.0559	0.049	-1.153	0.249	-0.151	0.039
DIVIDENDPAYOUT	0.0742	0.009	8.47	0	0.057	0.091
LN_MARKETVALUE	0.3779	0.018	20.572	0	0.342	0.414
Ln_TOTALASSETS	0.3748	0.023	16.634	0	0.331	0.419
LN_AGEINCO	0.1324	0.037	3.585	0	0.06	0.205
Ln_AGEAFTERLISTING	-0.1502	0.025	-5.891	0	-0.2	-0.1
DUMMY_CHEMICAL	0.1432	0.028	5.045	0	0.088	0.199

RSS for DEBTTOEQUITY: 63854.54602063996
RSS for LN_CASH_ADJ: 105691.59751964002

4. DV: PATENT COUNT (APPLICATION) – 4 YEARS LAG FROM FINANCIAL STRUCTURE

Current function value: 4.449177						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCOUNT419	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1456			
Method:	MLE	**Df Model:**	11			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2786			
Time:	9:06:48	**Log-Likelihood:**	-6531.4			
converged:	TRUE	**LL-Null:**	-9053.5			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-9.0289	0.261	-34.564	0	-9.541	-8.517
DEBTTOEQUITY	0.1381	0.014	9.682	0	0.11	0.166
RD_SALERATIO	4.4226	0.707	6.256	0	3.037	5.808
DEBTTOEQUITY:RD_SALERATIO	0.0356	0.251	0.142	0.887	-0.455	0.527
LN_CASH_ADJ	0.0652	0.004	15.03	0	0.057	0.074
LN_CASH_ADJ:RD_SALERATIO	0.0111	0.056	0.198	0.843	-0.099	0.121
DIVIDENDPAYOUT	0.0803	0.009	8.893	0	0.063	0.098
LN_MARKETVALUE	0.3884	0.019	20.718	0	0.352	0.425
Ln_TOTALASSETS	0.3459	0.023	15.004	0	0.301	0.391
LN_AGEINCO	0.1502	0.038	3.996	0	0.077	0.224
Ln_AGEAFTERLISTING	-0.2063	0.026	-7.998	0	-0.257	-0.156
DUMMY_CHEMICAL	0.124	0.03	4.195	0	0.066	0.182

RSS for DEBTTOEQUITY: 53532.67403763128
RSS for LN_CASH_ADJ: 107695.72153663108

***Main IV: The Interaction of Debt to Equity Ratio* R&D Expenditure to Sales Ratio AND The Interaction of Ln Cash Flow* R&D Expenditure to Sales Ratio**

1. **DV: PATENT COUNT (PUBLICATION) – 1 YEAR LAG FROM PATENT APPLICATION**

Current function value: 5.066852						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTPUB116	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1456			
Method:	MLE	**Df Model:**	11			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2694			
Time:	9:11:44	**Log-Likelihood:**	-7438.1			
converged:	TRUE	**LL-Null:**	-10181			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-8.3194	0.236	-35.311	0	-8.781	-7.858
DEBTTOEQUITY	0.0938	0.013	7.222	0	0.068	0.119
RD_SALERATIO	2.7997	0.628	4.456	0	1.568	4.031
DEBTTOEQUITY:RD_SALERATIO	0.7657	0.228	3.362	0.001	0.319	1.212
LN_CASH_ADJ	0.034	0.003	9.928	0	0.027	0.041
LN_CASH_ADJ:RD_SALERATIO	0.075	0.05	1.499	0.134	-0.023	0.173
DIVIDENDPAYOUT	0.0421	0.008	4.994	0	0.026	0.059
LN_MARKETVALUE	0.3739	0.017	22.176	0	0.341	0.407
Ln_TOTALASSETS	0.3679	0.021	17.755	0	0.327	0.408
LN_AGEINCO	0.0743	0.034	2.205	0.027	0.008	0.14
Ln_AGEAFTERLISTING	-0.1737	0.023	-7.414	0	-0.22	-0.128
DUMMY_CHEMICAL	0.1461	0.027	5.467	0	0.094	0.199

RSS for DEBTTOEQUITY: 74471.7202676895
RSS for LN_CASH_ADJ: 98867.31576668951

2. DV: PATENT COUNT (PUBLICATION) – 2 YEARS LAG FROM PATENT APPLICATION

Current function value: 4.862908						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTPUB217	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1456			
Method:	MLE	**Df Model:**	11			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.279			
Time:	9:17:20	**Log-Likelihood:**	-7138.7			
converged:	TRUE	**LL-Null:**	-9900.6			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-8.6087	0.241	-35.77	0	-9.08	-8.137
DEBTTOEQUITY	0.0861	0.013	6.387	0	0.06	0.112
RD_SALERATIO	3.8604	0.599	6.44	0	2.686	5.035
DEBTTOEQUITY:RD_SALERATIO	0.7121	0.228	3.127	0.002	0.266	1.158
LN_CASH_ADJ	0.0443	0.004	12.246	0	0.037	0.051
LN_CASH_ADJ:RD_SALERATIO	0.0004	0.048	0.008	0.994	-0.094	0.094
DIVIDENDPAYOUT	0.0497	0.009	5.828	0	0.033	0.066
LN_MARKETVALUE	0.3701	0.017	21.382	0	0.336	0.404
Ln_TOTALASSETS	0.3714	0.021	17.469	0	0.33	0.413
LN_AGEINCO	0.0951	0.035	2.753	0.006	0.027	0.163
Ln_AGEAFTERLISTING	-0.1664	0.024	-6.937	0	-0.213	-0.119
DUMMY_CHEMICAL	0.1175	0.027	4.305	0	0.064	0.171

RSS for DEBTTOEQUITY: 72579.18559573442
RSS for LN_CASH_ADJ: 100340.65909473436

3. DV: PATENT COUNT (PUBLICATION) – 3 YEARS LAG FROM PATENT APPLICATION

Current function value: 4.847210						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTPUB318	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1456			
Method:	MLE	**Df Model:**	11			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2819			
Time:	9:22:22	**Log-Likelihood:**	-7115.7			
converged:	TRUE	**LL-Null:**	-9909.6			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-8.709	0.242	-35.914	0	-9.184	-8.234
DEBTTOEQUITY	0.0986	0.014	7.222	0	0.072	0.125
RD_SALERATIO	3.2448	0.654	4.962	0	1.963	4.527
DEBTTOEQUITY:RD_SALERATIO	0.5065	0.235	2.152	0.031	0.045	0.968
LN_CASH_ADJ	0.0455	0.004	12.362	0	0.038	0.053
LN_CASH_ADJ:RD_SALERATIO	0.061	0.052	1.176	0.24	-0.041	0.163
DIVIDENDPAYOUT	0.0706	0.008	8.39	0	0.054	0.087
LN_MARKETVALUE	0.3867	0.018	22.026	0	0.352	0.421
Ln_TOTALASSETS	0.3551	0.021	16.519	0	0.313	0.397
LN_AGEINCO	0.0905	0.035	2.569	0.01	0.021	0.16
Ln_AGEAFTERLISTING	-0.0991	0.025	-4.01	0	-0.148	-0.051
DUMMY_CHEMICAL	0.1213	0.027	4.421	0	0.068	0.175

RSS for DEBTTOEQUITY: 72682.6942353301
RSS for LN_CASH_ADJ: 101369.11573433023

4. DV: PATENT COUNT (PUBLICATION) – 4 YEARS LAG FROM PATENT APPLICATION

Current function value: 4.806120						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTPUB419	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1456			
Method:	MLE	**Df Model:**	11			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.278			
Time:	9:28:21	**Log-Likelihood:**	-7055.4			
converged:	TRUE	**LL-Null:**	-9771.4			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-8.5502	0.244	-34.987	0	-9.029	-8.071
DEBTTOEQUITY	0.0854	0.014	6.142	0	0.058	0.113
RD_SALERATIO	2.8796	0.687	4.194	0	1.534	4.225
DEBTTOEQUITY:RD_SALERATIO	0.7945	0.234	3.4	0.001	0.337	1.252
LN_CASH_ADJ	0.0512	0.004	13.406	0	0.044	0.059
LN_CASH_ADJ:RD_SALERATIO	0.0826	0.054	1.521	0.128	-0.024	0.189
DIVIDENDPAYOUT	0.0528	0.009	6.13	0	0.036	0.07
LN_MARKETVALUE	0.3611	0.018	20.322	0	0.326	0.396
Ln_TOTALASSETS	0.3574	0.022	16.424	0	0.315	0.4
LN_AGEINCO	0.067	0.035	1.89	0.059	-0.002	0.136
Ln_AGEAFTERLISTING	-0.0637	0.025	-2.533	0.011	-0.113	-0.014
DUMMY_CHEMICAL	0.1093	0.028	3.948	0	0.055	0.164

RSS for DEBTTOEQUITY: 70143.10844854673
RSS for LN_CASH_ADJ: 100514.25794754681

Main IV: The Interaction of Debt to Equity Ratio* R&D Expenditure to Sales Ratio AND The Interaction of Ln Cash Flow* R&D Expenditure to Sales Ratio

1. DV: PATENT COUNT (CITATION) – WITHIN 3 YEARS FROM PATENT PUBLICATION

Current function value: 4.416372						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCITATION514	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1456			
Method:	MLE	**Df Model:**	11			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.2929			
Time:	9:33:17	**Log-Likelihood:**	-6483.2			
converged:	TRUE	**LL-Null:**	-9168.6			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-11.9064	0.299	-39.806	0	-12.493	-11.32
DEBTTOEQUITY	0.0301	0.017	1.721	0.085	-0.004	0.064
RD_SALERATIO	6.67	0.601	11.103	0	5.493	7.847
DEBTTOEQUITY:RD_SALERATIO	0.6835	0.266	2.572	0.01	0.163	1.204
LN_CASH_ADJ	0.0495	0.005	10.957	0	0.041	0.058
LN_CASH_ADJ:RD_SALERATIO	-0.2038	0.05	-4.117	0	-0.301	-0.107
DIVIDENDPAYOUT	0.1319	0.009	14.08	0	0.114	0.15
LN_MARKETVALUE	0.3861	0.021	18.399	0	0.345	0.427
Ln_TOTALASSETS	0.5755	0.026	21.935	0	0.524	0.627
LN_AGEINCO	0.0985	0.04	2.468	0.014	0.02	0.177
Ln_AGEAFTERLISTING	-0.5685	0.027	-21.255	0	-0.621	-0.516
DUMMY_CHEMICAL	0.2537	0.033	7.778	0	0.19	0.318

RSS for DEBTTOEQUITY: 40526.43693956207
RSS for LN_CASH_ADJ: 129309.656438562

2. DV: PATENT COUNT (CITATION) – WITHIN 4 YEARS FROM PATENT PUBLICATION

Current function value: 4.244963						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCITATION614	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1456			
Method:	MLE	**Df Model:**	11			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.3043			
Time:	9:37:37	**Log-Likelihood:**	-6231.6			
converged:	TRUE	**LL-Null:**	-8957.2			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-12.3478	0.313	-39.439	0	-12.961	-11.734
DEBTTOEQUITY	0.0301	0.018	1.662	0.096	-0.005	0.066
RD_SALERATIO	4.3426	0.83	5.234	0	2.716	5.969
DEBTTOEQUITY:RD_SALERATIO	0.8491	0.29	2.925	0.003	0.28	1.418
LN_CASH_ADJ	0.0462	0.005	9.654	0	0.037	0.056
LN_CASH_ADJ:RD_SALERATIO	-0.0263	0.066	-0.397	0.691	-0.156	0.104
DIVIDENDPAYOUT	0.141	0.01	14.488	0	0.122	0.16
LN_MARKETVALUE	0.4467	0.022	20.767	0	0.405	0.489
Ln_TOTALASSETS	0.5676	0.027	20.927	0	0.514	0.621
LN_AGEINCO	0.1663	0.041	4.049	0	0.086	0.247
Ln_AGEAFTERLISTING	-0.7032	0.027	-26.114	0	-0.756	-0.65
DUMMY_CHEMICAL	0.2425	0.034	7.136	0	0.176	0.309

RSS for DEBTTOEQUITY: 36358.15404380024
RSS for LN_CASH_ADJ: 135483.9475428002

3. DV: PATENT COUNT (CITATION) – WITHIN 5 YEARS FROM PATENT PUBLICATION

Current function value: 4.017844						
Iterations 7						
Poisson Regression Results						
Dep. Variable:	PATENTCITATION714	**No. Observations:**	1468			
Model:	Poisson	**Df Residuals:**	1456			
Method:	MLE	**Df Model:**	11			
Date:	Tue, 09 Jan 2024	**Pseudo R-squ.:**	0.3164			
Time:	9:41:22	**Log-Likelihood:**	-5898.2			
converged:	TRUE	**LL-Null:**	-8627.9			
Covariance Type:	nonrobust	**LLR p-value:**	0			
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-12.3268	0.328	-37.533	0	-12.97	-11.683
DEBTTOEQUITY	0.0979	0.018	5.55	0	0.063	0.133
RD_SALERATIO	1.9609	1.156	1.696	0.09	-0.305	4.227
DEBTTOEQUITY:RD_SALERATIO	0.7511	0.304	2.47	0.014	0.155	1.347
LN_CASH_ADJ	0.0485	0.005	9.186	0	0.038	0.059
LN_CASH_ADJ:RD_SALERATIO	0.1953	0.091	2.147	0.032	0.017	0.374
DIVIDENDPAYOUT	0.1533	0.01	14.823	0	0.133	0.174
LN_MARKETVALUE	0.5566	0.022	25.594	0	0.514	0.599
Ln_TOTALASSETS	0.476	0.028	17.162	0	0.422	0.53
LN_AGEINCO	0.2933	0.043	6.816	0	0.209	0.378
Ln_AGEAFTERLISTING	-0.7999	0.027	-29.184	0	-0.854	-0.746
DUMMY_CHEMICAL	0.2264	0.036	6.365	0	0.157	0.296

RSS for DEBTTOEQUITY: 31967.27516776152
RSS for LN_CASH_ADJ: 142699.40466676152

APPENDIX 3: OECD Industrial Classification

	High-tech	Low-tech
Manufacturing	Air and spacecraft and related machinery; Pharmaceuticals; Computer, electronic and optical products; Weapons and ammunition; Motor vehicles, trailers and semi-trailers; Medical and dental instruments; Machinery and equipment n.e.c; Chemicals and chemical products Electrical equipment; Railroad, military vehicles and transport	Rubber and plastic products; Building of ships and boats; Other manufacturing except medical and dental instruments; Other non-metallic mineral products Basic metals; Repair and installation of machinery and equipment; Textiles; Leather and related products; Paper and paper products; Food products, beverages and tobacco Wearing apparel; Fabricated metal products except weapons and ammunition; Coke and refined petroleum products Furniture; Wood and products of wood and cork; Printing and reproduction of recorded media;
Non-Manufacturing	Scientific research and development; Software publishing; IT and other information services	Professional, scientific and technical activities except scientific R&D; Telecommunications; Mining and quarrying; Publishing of books and periodicals; Financial and insurance activities; Electricity, gas and water supply, waste management and remediation; Audiovisual and broadcasting activities Wholesale and retail trade; Agriculture, forestry and fishing; Construction; Administrative and support service activities; Arts, entertainment, repair of household goods and other services; Transportation and storage; Accommodation and food service activities; Real estate activities;

Appendix 4. JAPANESE UNDER WRITERS LIST

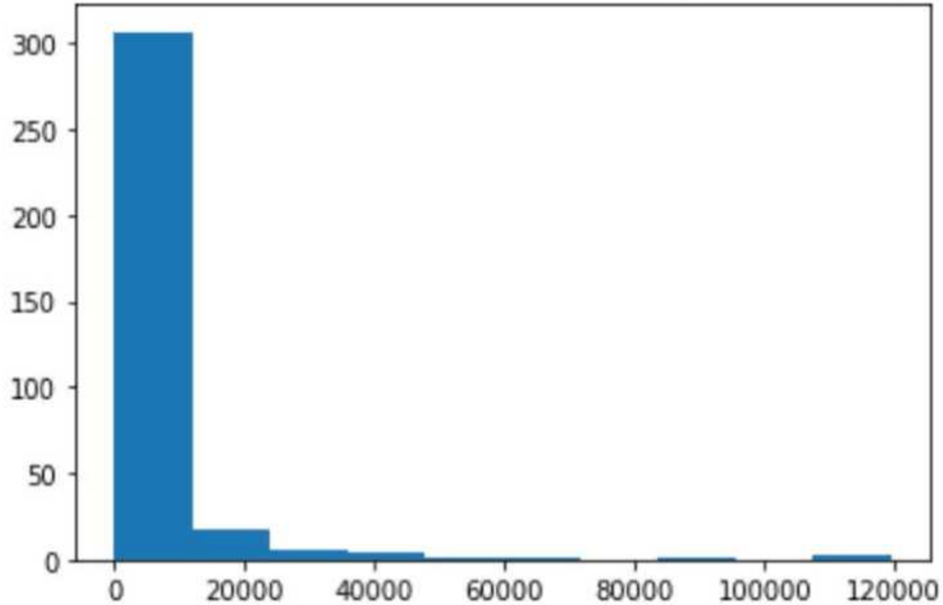
Number	Name of Underwriter
1	MIZUHO SECURITIES
2	NOMURA SECURITIES
3	DAIWA SECURITIES
4	MISTUBISHI UFJ MORGAN STANLEY
5	SMBC NIKKO SECURITIES
6	HS SECURITIES
7	ICHIYOSHI SECURITIES
8	SECURITIES
9	MIZUHO SECURITIES
10	NOMURA SECURITIES
11	OKASAN SECURITIES
12	SBI SECURITIES
13	SMBC FRIEND SECURITIES
14	TOKAI TOKYO SECURITIES

Appendix 5. STOCK MARKET EXCHANGE IN JAPAN

Stock	Definition
FSE	Fukuoka Stock Exchange: one of the local stock exchanges;
FSEQ	Fukuoka Stock Exchange "Q-Board": a market for start-up companies newly established by FSE in May 2000;
HRLS	Hercules: a market for start-up firms newly established by OSE in December 20002 after the close of NASDAQ-Japan;
HSE	Hiroshima Stock Exchange: one of the local stock exchanges, closed in March 2000
JAQ	JASDAQ Securities Exchanges: converted from OTC in December 2004
MTH	Mothers: a market for start-up firms newly established by TSE in November 1999
NASJ	NASDAQ- Japan: closed in October 2002
NEO	NEO: a market for start-up firms newly establishes by JASDAQ in May 2007
NSE2	Nagoya Stock Exchange 2nd Section
NSEC	Nagoya Stock Exchange "Centrex": a market for start-up firms newly established NSE in October 1999
OSE2	Osaka Securities Exchange 2nd Section
ONSEN	Osaka Securities Exchange New Market Section (taken over by HRLS in April 2003)
OTC	Over-the-counter market: operated by Japan Securities Dealers Association and converted into JAQ in December 2004
SSE	Sapporo Securities Exchange: one of the local stock exchanges
TSE	Tokyo Stock exchange Section

Appendix 6. Descriptive Statistic Result for Chapter 4

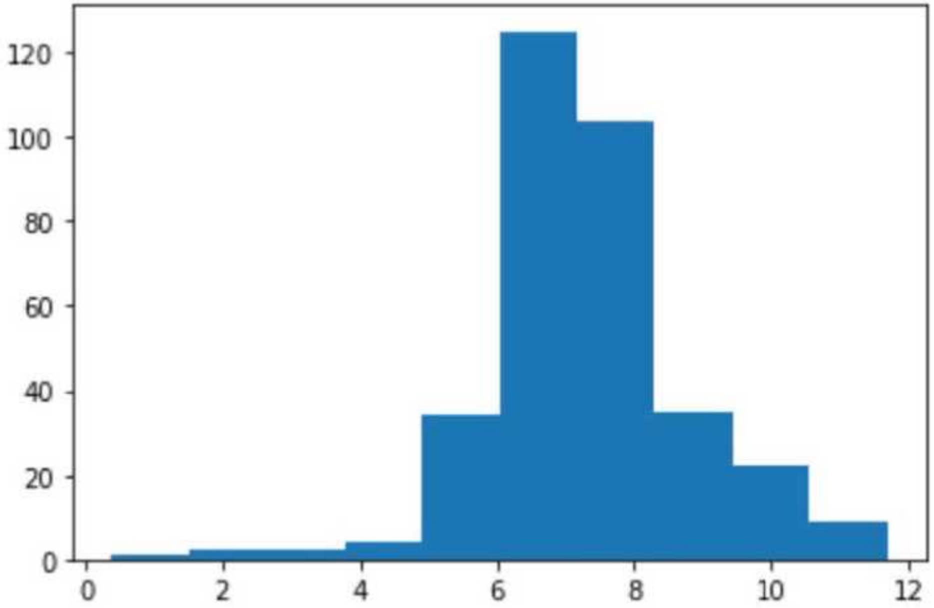
Histogram PROCEED (original data)



count	338.000000
mean	4878.915725
std	12479.669023
min	1.470000
25%	680.000000
50%	1310.000000
75%	3244.775000
max	119441.250000

Name: PROCEED

Histogram LN_PROCEED (Natural Log data)



count	338.000000
mean	7.353864
std	1.441044
min	0.385262
25%	6.522093
50%	7.177753
75%	8.084769
max	11.690580

Name: LN_Proceed

Correlation Matrix (Independent Variable: PAT4)

	PROCEED	PAT4	Ln_Employ	LN_AGENEW	ln_DE	NEWHI1_OECD	UW_5	TOKYO_Tokyo	VC_OT1
PROCEED	1	0.529412301	0.472528412	-0.051772521	0.045136728	0.084184022	0.066728537	0.380581523	-0.055704567
PAT4	0.529412301	1	0.311194858	-0.117389135	0.041614124	0.056208055	0.015289865	0.229540489	-0.023260197
Ln_Employ	0.472528412	0.311194858	1	0.370853473	0.315199874	-0.063200894	0.098137277	0.5108269	-0.234505118
LN_AGENEW	-0.051772521	-0.117389135	0.370853473	1	0.372076385	-0.114378463	0.171229667	0.241696592	-0.115593631
ln_DE	0.045136728	0.041614124	0.315199874	0.372076385	1	-0.125146277	0.037952293	0.148343879	-0.18220449
NEWHI1_OECD	0.084184022	0.056208055	-0.063200894	-0.114378463	-0.125146277	1	0.033321426	0.067922334	-0.032090051
UW_5	0.066728537	0.015289865	0.098137277	0.171229667	0.037952293	0.033321426	1	0.188195646	0.099769886
TOKYO_Tokyo	0.380581523	0.229540489	0.5108269	0.241696592	0.148343879	0.067922334	0.188195646	1	-0.193780653
VC_OT1	-0.055704567	-0.023260197	-0.234505118	-0.115593631	-0.18220449	-0.032090051	0.099769886	-0.193780653	1

Correlation Matrix (Independent Variable: PAT5)

	PROCEED	PAT5	Ln_Employ	LN_AGENEW	ln_DE	NEWHI1_OECD	UW_5	TOKYO_Tokyo	VC_OT1
PROCEED	1	0.497807579	0.472528412	-0.051772521	0.045136728	0.084184022	0.066728537	0.380581523	-0.055704567
PAT5	0.497807579	1	0.294613906	-0.119966388	0.036799862	0.055307083	0.018374202	0.211258579	-0.026809324
Ln_Employ	0.472528412	0.294613906	1	0.370853473	0.315199874	-0.063200894	0.098137277	0.5108269	-0.234505118
LN_AGENEW	-0.051772521	-0.119966388	0.370853473	1	0.372076385	-0.114378463	0.171229667	0.241696592	-0.115593631
ln_DE	0.045136728	0.036799862	0.315199874	0.372076385	1	-0.125146277	0.037952293	0.148343879	-0.18220449
NEWHI1_OECD	0.084184022	0.055307083	-0.063200894	-0.114378463	-0.125146277	1	0.033321426	0.067922334	-0.032090051
UW_5	0.066728537	0.018374202	0.098137277	0.171229667	0.037952293	0.033321426	1	0.188195646	0.099769886
TOKYO_Tokyo	0.380581523	0.211258579	0.5108269	0.241696592	0.148343879	0.067922334	0.188195646	1	-0.193780653
VC_OT1	-0.055704567	-0.026809324	-0.234505118	-0.115593631	-0.18220449	-0.032090051	0.099769886	-0.193780653	1

Appendix 7. Main Result for Chapter 4

Hypothesis 1:

Independent Variable: PAT4

Dep. Variable:	LN_Proceed	**R-squared:**	0.291
Model:	OLS	**Adj. R-squared:**	0.273
Method:	Least Squares	**F-statistic:**	16.84
Date:	Sat, 30 Dec 2023	**Prob (F-statistic):**	5.96E-21
Time:	3:17:29	**Log-Likelihood:**	-544.59
No. Observations:	338	**AIC:**	1107
Df Residuals:	329	**BIC:**	1142
Df Model:	8		

	coef	**std err**	**t**	**P>ltl**	**[0.025**	**0.975]**
Intercept	5.7756	0.391	14.78	0	5.007	6.544
PAT4	0.0005	0	2.013	0.045	1.11E-05	0.001
Ln_Employ	0.3871	0.058	6.636	0	0.272	0.502
LN_AGENEW	-0.3537	0.093	-3.812	0	-0.536	-0.171
ln_DE	-0.0575	0.062	-0.932	0.352	-0.179	0.064
NEWHI1_OECD	0.3203	0.151	2.116	0.035	0.022	0.618
UW_5	0.2776	0.166	1.674	0.095	-0.049	0.604
TOKYO_Tokyo	0.489	0.193	2.53	0.012	0.109	0.869
VC_OT1	-0.1517	0.147	-1.033	0.302	-0.441	0.137

Omnibus:	59.627	**Durbin-Watson:**	1.69	**Skew:**	-0.818	**Prob(JB):**	5.88E-36
Prob(Omnibus):	0	**Jarque-Bera (JB):**	162.242	**Kurtosis:**	5.974	**Cond. No.**	1.88E+03

Hypothesis 1:
Independent Variable: PAT5

Dep. Variable:	LN_Proceed	**R-squared:**	0.289
Model:	OLS	**Adj. R-squared:**	0.272
Method:	Least Squares	**F-statistic:**	16.72
Date:	Sat, 30 Dec 2023	**Prob (F-statistic):**	8.34E-21
Time:	3:17:29	**Log-Likelihood:**	-544.95
No. Observations:	338	**AIC:**	1108
Df Residuals:	329	**BIC:**	1142
Df Model:	8		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
Intercept	5.7679	0.391	14.748	0	4.999	6.537
PAT5	0.0003	0	1.827	0.069	-2.53E-05	0.001
Ln_Employ	0.3917	0.058	6.735	0	0.277	0.506
LN_AGENEW	-0.3592	0.093	-3.873	0	-0.542	-0.177
ln_DE	-0.0569	0.062	-0.92	0.358	-0.178	0.065
NEWHI1_OECD	0.3221	0.152	2.125	0.034	0.024	0.62
UW_5	0.275	0.166	1.657	0.098	-0.051	0.601
TOKYO_Tokyo	0.4982	0.193	2.579	0.01	0.118	0.878
VC_OT1	-0.147	0.147	-1.001	0.318	-0.436	0.142

Omnibus:	59.596	**Durbin-Watson:**	1.688	**Skew:**	-0.819	**Prob(JB):**	7.88E-36
Prob(Omnibus):	0	**Jarque-Bera (JB):**	161.658	**Kurtosis:**	5.966	**Cond. No.**	2.50E+03

Appendix 8. Descriptive Statistic Result for Chapter 5

Descriptive Statistic with High-tech Sample

	PROCEED	FOURY	TOTALPRE_IPO	Employee	AGE	DEBTEQUITY	NEWHI1_OECD	UW_5	TOKYO_Tokyo	VC_OT1
count	242	242	242	242	242	242	242	242	242	242
mean	5539.635	66.75207	83.21901	1066.711	24.96694	2.030865	1	0.780992	0.239669	0.35124
std	14215.99	355.3513	474.738	3404.823	19.74524	3.142394	0	0.414431	0.427766	0.478347
min	46.32	0	1	8	1	-6.11656	1	0	0	0
25%	720	3	3	80	9	0.608294	1	1	0	0
50%	1286	8	9.5	206	20	1.404126	1	1	0	0
75%	3363.75	25.75	27.75	600.75	37	2.509455	1	1	0	1
max	119441.3	4879	6721	36858	101	38.66667	1	1	1	1

Descriptive Statistic with Low-tech Sample

	PROCEED	FOURY	TOTALPRE_IPO	Employee	AGE	DEBTEQUITY	NEWHI1_OECD	UW_5	TOKYO_Tokyo	VC_OT1
count	96	96	96	96	96	96	96	96	96	96
mean	3213.351	29.03125	33.71875	743.6563	31.28125	3.087535	0	0.75	0.177083	0.385417
std	5989.836	66.91101	77.7503	2127.505	21.96107	5.654714	0	0.435286	0.383743	0.489248
min	1.47	0	1	22	2	-1.70833	0	0	0	0
25%	585	2.75	3	129.25	10	0.898774	0	0.75	0	0
50%	1326.5	7.5	9	255.5	30	1.807419	0	1	0	0
75%	2870	27.25	32.5	601	48.25	2.971094	0	1	0	1
max	43200	485	564	20117	93	48.01316	0	1	1	1

Appendix 9. Main Result for Chapter 5

Hypothesis 1:
Independent Variable: PAT4, Industrial Classification OECD

OLS Regression Results			
Dep. Variable:	LN_Proceed	**R-squared:**	0.298
Model:	OLS	**Adj. R-squared:**	0.278
Method:	Least Squares	**F-statistic:**	15.44
Date:	Sat, 30 Dec 2023	**Prob (F-statistic):**	5.29E-21
Time:	8:39:49	**Log-Likelihood:**	-542.89
No. Observations:	338	**AIC:**	1106
Df Residuals:	328	**BIC:**	1144
Df Model:	9		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|
Intercept	5.6705	0.394	14.405	0
C(NEWHI1_OECD)[T.1]	0.2144	0.081	2.644	0.009
PAT4	0.004	0.002	2.062	0.04
PAT4:C(NEWHI1_OECD)[T.1]	-0.0035	0.002	-1.823	0.069
Ln_Employ	0.3847	0.058	6.617	0
LN_AGENEW	-0.3442	0.093	-3.716	0
ln_DE	-0.0557	0.062	-0.906	0.366
NEWHI1_OECD	0.2144	0.081	2.644	0.009
UW_5	0.278	0.165	1.683	0.093
TOKYO_Tokyo	0.4285	0.195	2.193	0.029
VC_OT1	-0.1611	0.146	-1.101	0.272

Omnibus:	53.144	**Durbin-Watson:**	1.699
Prob(Omnibus):	0	**Jarque-Bera (JB):**	139.481
Skew:	-0.741	**Prob(JB):**	5.15E-31
Kurtosis:	5.776	**Cond. No.**	1.47E+18

Hypothesis 1:
Independent Variable: PAT5, Industrial Classification OECD

OLS Regression Results

Dep. Variable:	LN_Proceed	**R-squared:**	0.297
Model:	OLS	**Adj. R-squared:**	0.278
Method:	Least Squares	**F-statistic:**	15.4
Date:	Sat, 30 Dec 2023	**Prob (F-statistic):**	6.09E-21
Time:	8:39:49	**Log-Likelihood:**	-543.04
No. Observations:	338	**AIC:**	1106
Df Residuals:	328	**BIC:**	1144
Df Model:	9		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**
Intercept	5.6627	0.393	14.399	0
C(NEWHI1_OECD)[T.1]	0.4364	0.162	2.692	0.007
TOTALPRE_IPO	0.0035	0.002	2.12	0.035

TOTALPRE_IPO:C(NEWHI1_OECD)[T.1]	-0.0032	0.002	-1.933	0.054
Ln_Employ	0.3884	0.058	6.703	0
LN_AGENEW	-0.3496	0.092	-3.78	0
ln_DE	-0.0548	0.062	-0.891	0.374
UW_5	0.2759	0.165	1.67	0.096
TOKYO_Tokyo	0.4347	0.195	2.228	0.027
VC_OT1	-0.1588	0.146	-1.085	0.279

Omnibus:	52.778	**Durbin-Watson:**	1.696
Prob(Omnibus):	0	**Jarque-Bera (JB):**	137.839
Skew:	-0.738	**Prob(JB):**	1.17E-30
Kurtosis:	5.759	**Cond. No.**	3.57E+03

Appendix 10. Robustness Check Result for Chapter 5

Hypothesis 1:
Independent Variable: PAT4, Industrial Classification Thomson Reuter

OLS Regression Results

Dep. Variable:	LN_Proceed	**R-squared:**	0.302
Model:	OLS	**Adj. R-squared:**	0.283
Method:	Least Squares	**F-statistic:**	15.79
Date:	Sat, 30 Dec 2023	**Prob (F-statistic):**	1.87E-21
Time:	8:39:49	**Log-Likelihood:**	-541.76
No. Observations:	338	**AIC:**	1104
Df Residuals:	328	**BIC:**	1142

Df Model:	9
Covariance Type:	nonrobust

	coef	std err	t	P>|t|
Intercept	5.6265	0.406	13.845	0
C(HI1_REUTER)[T.1]	0.2085	0.077	2.724	0.007
PAT4	0.0016	0.001	3.011	0.003
PAT4:C(HI1_REUTER)[T.1]	-0.0013	0.001	-2.25	0.025
Ln_Employ	0.364	0.058	6.231	0
LN_AGENEW	-0.2842	0.096	-2.946	0.003
ln_DE	-0.0614	0.061	-1.004	0.316
HI1_REUTER	0.2085	0.077	2.724	0.007
UW_5	0.3146	0.165	1.902	0.058
TOKYO_Tokyo	0.4818	0.192	2.515	0.012
VC_OT1	-0.2084	0.147	-1.418	0.157

Omnibus:	64.339	**Durbin-Watson:**	1.699
Prob(Omnibus):	0	**Jarque-Bera (JB):**	190.322
Skew:	-0.853	**Prob(JB):**	4.70E-42
Kurtosis:	6.256	**Cond. No.**	5.17E+18

Prob(Omnibus):	0	**Jarque-Bera (JB):**	194.227
Skew:	-0.887	**Prob(JB):**	6.67E-43
Kurtosis:	6.262	**Cond. No.**	1.97E+03

Hypothesis 1:
Independent Variable: PAT5, Industrial Classification Thomson Reuter

OLS Regression Results

Dep. Variable:	LN_Proceed	**R-squared:**	0.304
Model:	OLS	**Adj. R-squared:**	0.284
Method:	Least Squares	**F-statistic:**	15.88
Date:	Sat, 30 Dec 2023	**Prob (F-statistic):**	1.42E-21
Time:	8:39:49	**Log-Likelihood:**	-541.47
No. Observations:	338	**AIC:**	1103
Df Residuals:	328	**BIC:**	1141
Df Model:	9		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>ltl**
Intercept	5.6253	0.406	13.859	0
C(HI1_REUTER)[T.1]	0.2132	0.076	2.788	0.006
PAT5	0.0014	0	3.153	0.002
PAT5:C(HI1_REUTER)[T.1]	-0.0012	0	-2.54	0.012
Ln_Employ	0.3652	0.058	6.272	0
LN_AGENEW	-0.2884	0.096	-2.999	0.003
ln_DE	-0.0595	0.061	-0.974	0.331
HI1_REUTER	0.2132	0.076	2.788	0.006
UW_5	0.3132	0.165	1.897	0.059
TOKYO_Tokyo	0.4891	0.191	2.56	0.011
VC_OT1	-0.2067	0.147	-1.409	0.16

Omnibus:	64.615	**Durbin-Watson:**	1.699

Prob(Omnibus):	0	**Jarque-Bera (JB):**	192.147
Skew:	-0.855	**Prob(JB):**	1.89E-42
Kurtosis:	6.274	**Cond. No.**	5.14E+18

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