

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

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Abstract — Prior studies pointed out evidences on Start-ups and Venture Capital (VC) companies use different measures for providing signals to outsiders. This study adds to the previous insight by focusing instead on established firm's patenting behaviors and their effect on the amount of money raised at the Initial Public Offering (IPO). Since technology intensity may considerably differ between High-tech and Low-tech companies, our main interest in this paper is whether the significance of pre-IPO patenting activities as a predictor of IPO performance is considerably different between High-tech Industry and Low-tech Industry. Using cross-sectional data for 308 Japanese industrial firm's commitments to IPO between 2000 and 2015, we find a robust positive correlation between patent applications and IPO performance. Contrary to the conventional wisdom proposing that High-tech firms with more patenting activities achieve better IPO performance, we find that the signaling power of patenting is stronger for Low-tech companies. In other words, while High-tech firms do not seem to benefit from a patent signal, Low-tech firms tend to attract external investors easier by patent at IPO.

Keywords - Patent, Signal, Initial Public Offering (IPO), High-tech Industries, Low-tech Industries.

I. INTRODUCTION

An Initial Public Offering (IPO) is an important event since companies can raise capital from public investors and gain a greater ability to grow and expand its business. It is impossible for outside investors to predict the long-term potential of an IPO company when objective financial information is unavailable. Indeed, convincing investors of their worth is a major challenge for any company going public. Firms usually use signals of quality such as increased transparency, and share listing credibility to attract capital from outside investors. Previous researchers have studied different measures to signal the quality of IPO companies to help to reduce uncertainty around IPO's performance. Research has suggested that trustworthy third-party affiliates such as venture capitalists [1], corporate partners [2], and auditors [3] can be a signal in IPO. Investor decisions can also be affected by entrepreneurial lineage, founder backgrounds [4,5], and underwriter prestige [6]. In addition, prior research identified the firm's internationalization [7]; inter-organizational networks [8] as key factors that reduce information asymmetry. However, modern investors no longer trust these signals at their face value because of their dynamic and evolving nature [9]. They look instead for concrete evidence of a company's innovation, such as patents, to gauge its potential. Patents may come to be a

crucial signal that has the power to reduce information asymmetries and maximize the attraction of investor capital. Patents have properties to serve as an ideal proxy to assess the quality assessment of firms: they are expensive to operate and observable by outsiders [10]. Firms may apply for a patent to leverage its performance-enhancing capabilities under conditions of uncertainty. For example, as firms near an IPO- a critical financing event, they are likely to increase their patenting activity to attract potential investors.

The degree of information asymmetry between a firm's insiders and outsiders varies depending on the technology intensity of the company. Information transparency is influenced by a company's patenting motive and the underlying technology of innovation. Technologies characteristic of High-tech sectors are primarily complex in nature and comprised of a large number of patentable components [11]. Therefore, High-tech firms may face difficulty clarifying patenting information that outsiders can use to assess their validity. Innovative portfolios of high-tech companies can be too sophisticated for outsiders to interpret and understand to the point where coherent guidance on assessing their commercial prospects cannot realistically be provided [12]. Informational asymmetry is more severe for high-tech firms and increases investor uncertainty. Therefore, the patenting activities of High-tech companies are less reliable as a signal of potential growth compared to those of traditional firms.

The purpose of this paper is twofold. Firstly, we explore whether firms' patenting practices prior to an IPO impact the way investors perceive their potential IPO performance. Second, we investigate whether patenting activities in High-tech and Low-tech industries with different technology intensity drive different investor behaviors when financing their money to IPO companies.

Empirical results from a sample of 308 IPOs issued by Japanese manufacturing firms during 2000 – 2015 strongly support our hypotheses. A significant and positive relationship was found between the number of patents filed during the five- years period immediately preceding an IPO and the amount of capital raised at IPO. These results indicate that a firm modifies their patent strategies by increasing the number of patent applications as the IPO nears. They do so to signal their firm's innovative rigor in order to improve IPO performance. This study also shows the significance of pre-IPO patenting activities as a

predictor of IPO performance and how it differs considerably between High-tech and Low-tech Industries. While High-tech firms do not seem to benefit from a patent quality signal, Low-tech firms tend to attract external financing more easily during IPO.

II. LITERATURE REVIEW

A. Patent as signal for IPO Performance:

Initial Public Offering (IPO) is a momentous event for any business since it provides an opportunity to gain capital from the public investors; increase and publicity; and present as a liquidity event for existing shareholders [13]. Yet IPO firms may face many disadvantages when raising capital since they are typically young companies with low liquidation value and unstable in their business operations [9]. In addition, information asymmetry—an inevitable issue associated with privately held companies—presents an additional hurdle for potential investors to confidently predict their financial performance. Therefore, it is important for any company going public to convince relevant audiences, particularly investors, that the firm has potential for long-term growth, thus it is worth investing in its shares [12]. Prior research found IPO firms employ a range of signals, including affiliations with third parties such as venture capitalists [14], corporate partners [15]; and auditors [16] to ease the uncertainty surrounding the IPO process and compensate for the perceived investment risk. Investors can also evaluate the following factors to decide whether or not to invest in an IPO company: entrepreneurial lineage and founder backgrounds [17,18]; board size and composition [19]; and underwriter prestige [20] and other signals as key factors that reduce information asymmetry. If uncertainty and information asymmetry can be minimized, patenting activities - evidence of innovation and competency- may also serve as a quality signal for IPO performance.

Before discussing the role of patents as a quality signal, it is necessary to review different motives for patenting as property rights. Companies file for patent protection most commonly to prevent infringement and secure an exclusive right to profit from their distinct product offerings [21]. Another important motive is to preempt competitors from acquiring patents on the same inventions and also block patents to prevent rivals from benefiting from their patents. [12,22]. Previous works posit those patents generate revenue in the form of licenses or develop an arsenal for cross-licensing negotiations over technology rights [23,24]. Existing literature also focuses on the role of patents as shields of protection from infringement suits, measurement of the internal performance of a firm's technologists [25]; substitutes for Non-Disclosure Agreements [26]; a reputation booster for companies [27,28]. The aforementioned motivations for filing patents are all aimed at generating revenue or reducing costs.

Another way to generate revenue is to gain capital through financial events such as IPO. And here is an important role of the patents serve as quality signals and

reduce information asymmetries between firms and outside investors. If a patenting company chooses to disclose, rather than withhold, invention information in the face of technology expropriation patents is a credible proxy transferring information about the underlying innovation [29]. In the view of outsiders, a company with a patent portfolio may appear capable of maintaining profits or even outperforming those without. Therefore, some companies attempt to own patents, especially before an IPO to enhance their perceived value to outsiders estimating their quality or worth.

Patents are valid quality signals because they are expensive to operate and can be easily observed and verified by outsiders. First, patents are costly signals because of the direct monetary costs associated with the administrative and attorneys' fees at roughly \$25,000 per patent in addition to the R&D expenditure that is often needed to generate a patentable invention [30]. Second, because patents are publicly available, outsiders can investigate their details through the public patent databases. Patents include verifiable information because Patent Offices require inventions to meet the following eligibility requirements: they must be new, industrially applicable, and involve an inventive step [31]. Patent Offices may help patenting companies strengthen credibility and add clarity to their inventions because patent granting authorities are viewed as reliable intermediaries, as in [9].

In some cases, patents do not directly serve as evidence characteristic of a firms' invention capabilities; however, they are still effective signals. A patent portfolio of a company may reveal its target markets (mass market or niche market) as well as Intellectual Property and Marketing Strategies [32]. The number of patent applications filed by a company served as a proxy for internal firm resources can reveal several key qualities that are otherwise difficult to measure. For example, patents may appear to investors that the company has innovative capabilities and technical expertise to codify tacit knowledge and hence signal R&D competencies of the company [33,21]. Altogether, patents communicate to target investors about a firm's growth potential at the time of initial public offering. In light of the patent signaling mechanism, we predict the following:

H1: All other conditions being equal, patent activities near an IPO signal IPO performance.

B. Patents Signal: High_tech VS. Low_Tech:

High-tech firms differ from Low-tech firms in a number of aspects. Firstly, high-tech firms commonly have fewer tangible assets but invest more in intangible assets such as R&D, human resources, information technology, patents and other intellectual property [11,34]. Inevitably, high-tech companies are often in a cash-shortage and constraint on tangible assets situation as compared to low-tech companies. Investors may perceive these shortfalls as a sign of manufacturing unavailability. Second, innovation projects can be implemented in several years, in some

special industries such as pharmaceutical, chemical innovation projects may take to decades. The company has to allocate a huge number of resources for the projects. Therefore, net income of high-tech firms is often negative or even have a huge loss in early years. This makes the valuation of the company quite conservative, investors largely depending on their expectation on future growth to evaluate the company rather than the objective assessment based on firm current values.

The degree of information friction between a firm's insiders and outsiders varies depending on the technology intensity of the company [35]. Technologies characteristic in High-tech firms are primarily complex in nature which are comprised of a large number of patentable components [36]. In this case, firms may face difficulty clarifying patenting information that outsiders can use to assess their validity [36]. Innovative portfolios of high-tech companies can be too sophisticated for outsiders to interpret and understand to the point where coherent guidance on assessing their commercial prospects cannot realistically be provided [35]. The informational asymmetry is more severe with regard to high-tech firms and thus increases investor uncertainty. Therefore, patents activities in High-tech companies are less reliable as signals of potential growth compared to those of traditional firms.

From the perspective of the High-tech firms, there is little incentive to file patents disclose innovation-related information to outsiders since doing so inevitably reveals competitively technology advantageous information to competitors. Low-tech companies with a relatively higher incentive of obtaining a patent and limited alternative way of achieving credibility are more eager to file for patents and thus Low-tech companies indicate a stronger patent signal to external. The corresponding hypotheses are developed as follows:

H2a: All other conditions being equal, there will be a positive relationship between patent activities of Low-tech companies near an IPO and its IPO performance.

H2b: All other conditions being equal, there will be a negative relationship between patent activities of High-tech companies near an IPO and its IPO performance.

III. METHODOLOGY

A. IPO sample and data:

Our research draws upon data from various sources: financial and corporate attribute data from Nikkei FinancialQUEST; Patent information from Japan Platform for Patent Information (J-PlatPat); IPO-related data from prospectuses and Japan Exchange Group (JPX) database; and industry classifications from OECD classification of Manufacturing Industries.

Information on Total proceeds was obtained from prospectuses filed by all Japanese companies that undertook IPOs between 2000 and 2015. The sampling period is decided with respect to stability in terms of market condition and regulatory setting regarding signaling

and disclosure. Up to 2000, IPO market was extremely hot and in hype due to dot-com. bubble and bio bubble and from 2016, Japanese IPO companies were subject to strict governance code due to the repetitive serious governance/disclosure scandals, which might force the IPO companies reconsider signaling strategy including disclosure. For Patenting data, we manually counted the number of patent applications filed by each IPO firm during the five- year periods leading up to the IPO date.

The research also investigates the effect of patents on IPO performance for firms in different industry groups. First, we referred to TSE New Industry Codes from Financial QUEST to select only companies operating in manufacturing industries and excluded firms belonging to non-manufacturing sectors. We then divided this sample into two sub-samples: High-tech Companies and Low-tech Companies using OECD classification of manufacturing industries. Final sample size of 308 manufacturing IPOs listed in the Japanese Stock Market Exchange between January 2000 and December 2015. At last, two sub-samples containing 186 High-tech Companies and 122 Low-tech Companies were available for analysis.

B. Variable Definition:

1) Independent Variable:

- *Patenting Activities: Number of Patent Application*

A patent performance in this research is defined as the total number of patents that a particular company has filed in the five- year period immediately before an IPO. We place an emphasis on this period because Patents offer a considerably short protection period of twenty years from the date of filling. Therefore, patents that were filed a long time ago may not reflect the current innovation performance of the firm [28]. A log-transformed variable of the number of patent applications ($\text{Log}(\text{Patent} + 1)$) is used to address the valuation data skew and reduce its heterogeneity.

2) Dependent Variable:

- *IPO Performance: Total Proceed*

We define our dependent variable Total Proceed as the amount of capital raised by firm i at the IPO date (t). The Total Proceed is calculated by multiplying the number of the total issue of firm i at the IPO date (t) by the issue price of firm i at the IPO date (t). This measure of IPO performance is appropriate for firms that tend to be cash-constrained and have a long and expensive development process, as in [37]. Furthermore, this method of evaluation avoids potential problems of over-allocation in the pre-money valuation [38]. To account for skewness in data, we use log transformation of Total Proceed.

3) Control Variable:

- *Firm size: Total Asset*

Previous research addresses that larger firms are expected to have less information asymmetry [39], and in general, have more patents. Therefore, we calculate the

logarithm of total assets one year before IPO to control for the size effect.

- *Firm Age: Age at IPO*

We calculate a firm's age by taking the natural logarithm of the difference between the date of its IPO and the date of its establishment. We expect the companies with a long history in its operation to have a better IPO performance than younger firms.

- *Underpricing: First-day Opening price*

Underpricing: Previous literature indicates that Underpricing is negatively related to IPO performance [40]. We define underpricing as the first-day opening price less the offer price divided by the offer price. Offer and opening prices data were obtained from the JPX database.

- *Financial Ratio: Debt Ratio*

A Debt Ratio is defined as a company's Total of Debt in proportion to its Total Assets in the year before IPO. It is a measure of a company's solvency and therefore, it is expected to influence the amount of capital that firms aim to raise from IPOs.

- *Prestigious underwriter backed: UW Dummy*

Firms with more prestigious underwriters tend to have better IPO performance [41]. We include a dummy variable called UW to measure the effect of underwriter reputation on the total proceed. UW is code 1 if the underwriter is one of the top three most famous underwriters in Japan: Daiwa Securities, Nomura Securities, or SMBC Nikko Securities and 0 otherwise.

- *Stock Market Effect: STOCK Dummy*

We introduce a dummy variable called "STOCK Dummy" which is coded 1 if the companies were quoted in "First Section" and "Second Section" Japanese stock exchanges and 0 otherwise. The First and Second Sections are collectively referred to the Main Markets where major and second-tier companies are listed [3]. Since most of the prominent companies are listed in First and Second Section, a positive relationship between Mother Market and IPO performance is expected.

- *Technological Intensity Dummies: High-tech and Low-tech:*

To estimate the differential effect of patenting on the IPO performance for companies in different industry groups, we include dummy variables that indicate the level of technological intensity between High-tech and Low-tech Industries. We used the OECD classification of manufacturing industries by technological intensity as shown in TABLE I to classify the manufacturing firms in our sample into two sectors: High-tech Companies and Low-tech Companies. We use 1 for companies belonging to the High-tech sector and 0 for otherwise. Similarly, we use 1 for companies belonging to the Low-tech sector and 0 for otherwise.

TABLE I. TSE NEW INDUSTRY CODE

Manufacturing	Non-Manufacturing
1. Construction	1. Electric Power & Gas
2. Foods	2. Land Transportation
3. Textiles & Apparels	3. Marine Transportation
4. Pulp & Paper	4. Air Transportation
5. Chemicals	5. Warehousing and Harbor Transportation
6. Pharmaceutical	6. Information & Communication
7. Oil & Coal Products	7. Wholesale Trade
8. Rubber Products	8. Retail Trade
9. Glass & Ceramic Products	9. Banks
10. Iron & Steel	10. Securities & Commodity Futures
11. Nonferrous Metals	11. Insurance
12. Metal Products	12. Other Financing Business
13. Electric Appliances	13. Real Estate
14. Transport Equipment	14. Service
15. Precision Instruments	15. Unclassifiable
16. Other Products	

- *Year Dummies:*

A set of yearly time dummy coded as 'Year2000' to 'Year2015' with year companies go public' is included to account for the overall business cycle effect.

IV. RESEARCH MODEL

To test the hypothesized relationship H1, we use the following ordinary least square regression:

$$LN(Total\ Proceed_i) = \beta_0 + \beta_1 * LN(Patent_i + 1) + \beta_2 * CVs + \epsilon_i (1)$$

Where:

- Total Proceed_i is the capital a firm i is able gain at the IPO date (t);
- Patent_i is the total patent application that was filed by a firm i in last five years until IPO date (t).
- CV is a vector of Control Variable.

Positive and significant β_1 is expected to support H1.

To estimate a differential effect of patenting on firm performance at IPO for the different industry groups, we include dummy variables that indicate technological intensity between High-tech and Low-tech Industries. We use the following OLS regression with the interaction term between Patenting and Technology Advantage for testing hypothesis H2a and H2b:

$$LN(Total\ Proceed_i) = \beta_0 + \beta_{11} * LN(Patent_i + 1) * Hightech_i + \beta_{12} * LN(Patent_i + 1) * Lowtech_i + \beta_2 * CVs + \epsilon_i (2)$$

Where:

- Total Proceed_i is the capital a firm i is able gain at the IPO date (t);
- Patent_i is the total patent application that was filed by a firm i in last five years until IPO date (t);
- High-tech: Dummy variable assigned a value of 1 if IPO company is High-tech company and 0 otherwise;

- Low-tech: Dummy variable assigned a value of 1 if IPO company is Low-tech company and 0 otherwise;
- CV is a vector of Control Variable.

Negative and significant β_{11} is expected to support H2a while positive and significant β_{12} is expected to support H2a

IV. FINDING AND RESULT

A. PRILIMINARY ANALYSIS:

TABLE II shows the correlation among variables. The correlation analysis is used to test any multicollinearity issues in variables and to scrutinize the presence of more than an extract linear correlation between independent variables. A severe multicollinearity between independent variables will offer the unnecessary bias in the regression results. Thus, a vigilant check should be made to verify its inexistence.

Some of the control variables show a negative correlation such as between underpricing and Ln(Total Asset), underpricing and LN(Age at IPO) and also between High-tech industries and Ln(Age of IPO). Meanwhile, some other control variables report a positive relationship such as Ln(Total Asset) and Ln(Age at IPO), High-tech industries and Debt Ratio, Underpricing and Debt Ratio. The sign of correlation indicates that some of the variables will have either similar or different types of changes in their paired-variable.

TABLE II. CORRELATION TABLE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	1.0									
(2)	.25	1.0								
(3)	.44	.39	1.0							
(4)	(-) .22	.27	.37	1.0						
(5)	.05	(-) .01	(-) .04	(-) .08	1.0					
(6)	(-) .18	(-) .05	(-) .25	(-) .17	(-) .06	1.0				
(7)	.22	.14	.23	.09	.10	(-) .05	1.0			
(8)	.27	.27	.38	.23	.00	(-) .03	.22	1.0		
(9)	.23	.22	(-) .77	(-) .11	.22	.00	.10	.08	1.0	
(10)	(-) .23	(-) .22	.07	.11	(-) .02	.00	(-) .10	(-) .08	(-) 1.0	1.0

Note: (1): Ln(Total Proceed); (2): Ln(Patent +1); (3):Ln(Total Asset); (4): Ln(Age at IPO); (5): Debt Ratio; (6): Underpricing; (7): UW Dummy; (8): STOCK Dummy; (9):High-tech Dummy; (10): Low-tech Dummy.

The highest correlation among control variables is between dummy variable IPO companies listed in between dummy variable IPO companies listed in Section 1 and Section2 Market (STOCK Dummy) and Ln(Total Asset) with a value of 0.38 with far lower than the cut-off point

0.9 [42]. Therefore, the value of coefficient in TABLE 6 indicates that there are no severe multicollinearity issues implying that all variables of this study pose an independent characteristic to justify their inclusion in the regression model.

B. MAIN ANALYSIS:

TABLE III summarizes the test results of the hypotheses built in this study. Model 1 presents the general impact of patents' signaling effect on IPO performance, while Model 2 illustrates the results on the signal effect of Patents in different groups differing degrees of impact between High-tech and Low-tech industries on IPO performance. Briefly, all hypothesized propositions built in this study are supported with significant effects.

Hypothesis 1 expects that patent activities near an IPO signal IPO performance. Ln(Patent+1) receives a positive coefficient (0.0548) and is highly significant (P-value <0.05); thus, Hypothesis 1 is qualified. It indicates that the greater the Patent activities near IPO-as measured by the number of Total Patent Applications in five years period immediately before IPO the better the outcome of the IPO performance. The current study was motivated by a gap in the literature on the role of patents as a quality signal for manufacturing firms. Our findings add to the existing knowledge -patents play a particularly valuable signaling role in the Start-up and Venture-Capital firms- by proving the importance of patents in attracting external financing for all industrial firms in general even if they have been in business for many years.

TABLE III. HYPOTHESES ANALYSIS RESULT

Variable	Model 1 (Hypothesis 1)	Model2 (Hypotheses 2a&2b)
Intercept	8.1871*** (0.826)	8.0856*** (0.814)
Ln(Patent+1)	0.0548** (0.041)	
High_tech*Ln(Patent+1)		-0.0585** (0.037)
Low_tech*Ln(Patent+1)		0.1313** (0.042)
Ln(Total Asset)	0.4804*** (0.058)	0.4861** (0.057)
Ln(Age at IPO)	-0.6793*** (0.089)	-0.6643*** (0.088)
Debt Ratio	0.1077 (0.640)	0.1000 (0.603)
Underpricing	-0.0019** (0.001)	-0.0018** (0.001)
UW Dummy	0.2512* (0.140)	0.1980 (0.139)
STOCK Dummy	0.5298*** (0.203)	0.5495*** (0.200)
High_tech Dummy	4.3290*** (0.410)	4.4879*** (0.408)
Low_Tech Dummy	3.8581*** (0.426)	3.5976*** (0.430)
Year Dummies	Yes	Yes
F-Value	24.43***	23.27***
Observation	308	308
Adjust R ²	0.446	0.462

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

In our next model (Model 2), we allow the patent signal to vary according to the industry group to which the firm belongs. In this study, we have defined two industry groups, high-tech and low-tech, according to differ in their characterized by technology intensity. The results provide strong support for Hypothesis 2a and Hypothesis 2b. Interaction term (Log (Patents+1) * High-tech) receives a negative coefficient (-0.0585) and P-value less than 0.05 indicates that, for high-tech firms, an increase in the patenting activities near IPO will reduce the money they collected from IPO. In comparison, the positive (0.1313) and significant ($p < 0.05$) interaction term (Log (Patents+1) * Low-tech) indicates that, for low-tech firms, the increasing the patenting activities near IPO will increase the money they collect at IPO.

The results of control variables are mostly consistent with the IPO literature for both models. The size of the firm (Total Asset) has a positive influence on Total Proceed in both models at the 1% significance level. Surprisingly, the impacts of the firm's age (Age at IPO) on IPO performance shows a reverse impact to what we expect. It is expected that companies with more history in operation before going public have better IPO performance than young companies. However, the result showing the effect of firm age size is negative for both Model 1 (-0.5696) and Model 2 (-0.5415) at the 1% significance level. Our explanation for this contrary result is that younger firms often invest relatively more in Innovation and patenting activities compared to older firms, and this helps reduce uncertainty about their quality to outsider investors, ultimately leading to better overall IPO performance. The effect of the financial indicator measured by Debt Ratio is not significant, providing no support for the relationship between a company's solvency and its IPO performance. Underpricing shows a negative and statistically significant sign that is consistent with our expectation. It implies that IPO companies probably reduce the price in order to maximize the share they sell, and in consequence it helps gain the Total Proceeding. Companies evaluated by prestigious underwriters appear more trustworthy in the eyes of investors, often achieving a successful IPO outcome.; this is proven by the positive (0.2512) in Model 1 and statistically significant ($P\text{-value} < 0.05$) of UW values. Stock market effect (STOCK Dummy), is significant at 0.01. STOCK Dummy produces a positive association to Total Proceed. First and Section sections offer a trading Market for companies which most prominent established companies are going to be listed. These companies tend to receive large sums of money from investors since they are perceived to may have steady growth in their future performance proxies that investors can easily interpret to fully benefit from the power of signals.

V. DISCUSSION AND CONCLUSION

Previous literature has suggested that signaling is an important and effective mechanism to reduce information asymmetry between a company and outside stakeholders. Our study adds to these insights by studying the patent

signal and its effect on one of the most significant events in a firm's life: IPO. We assert that firms adjust their patent strategies and increase the number of patents they file as the IPO date draws near to signal the quality of their enterprise. Companies usually seek an internal proxy that can signal their potential value to outsiders to maximize their IPO performance. Theoretically, patents are property rights that protect an invention and prevent infringement from rivals. Because patents are expensive in the operation and can be observed by outsiders and for those characteristics, they are also clearly applicable to be a function as a signal of a company's performance.

In addition, we developed and tested a model to show how the signaling effect of Patents differs between High-tech and Low-tech IPOs. Our results show that Low-tech firms strategically use patent applications to boost their IPO performance. Patent signals bring more benefits to Low-tech firms and help them improve their IPO performance.

High-tech firms have technologies that are primarily complex in nature; one invention can be comprised of a large number of patentable elements. Their innovative activities are much less well understood by outside observers, since historical patent data offer little guidance in assessing the prospects of their current patent activities. To interpret the value of an invention, outsider investors should be knowledgeable about the underlying technology; all patents associated with the invention and their relationships; and how the patents relate to other similar inventions. In addition, investors have to have an understanding of the overall innovation projects of the company to be able to discern which invention will likely generate a profit in the future, if at all, and the potential timeframe for when they can expect a return on their investment. These considerations suggest that informational frictions are more severe with regard to high-tech firms, and IPO investors may not be able to fully interpret the rich information the patent system provides on the quality of their technologies. In this context, patents do not reduce information asymmetries associated with innovation activities. Investors are reluctant to lend their money to high-tech companies with a complicated patent portfolio because they can be eager to allocate excessive resources to Innovation Projects which are risky and highly intangible. It goes without saying that investors gain nothing but lose everything if all projects fail and the firm defaults.

In contrast, most companies in the Low-tech sector tend to have a simpler innovation portfolio consisting of relatively few patentable elements, making the assessment and evaluation of patent activities considerably easy for outsiders. Low-tech companies seem to allocate resources in a balanced manner between intangible assets for innovation projects and tangible assets such as plant and machinery equipment that are essential for daily operation. This balanced approach to resource allocation makes investors confident in the long-term development of firms

and helps them view patents as a signal of company quality. In consequence, Low-tech companies raise more money from investors through an IPO than high-tech firms that do not really benefit from patent signals.

This study has some limitations that may present a fruitful direction for future research. Second, many investors may consider both the quality and quantity of patents, not one or the other, when they evaluate the patent activities of a company. The absence of qualitative considerations may have affected our findings, as we used the number of applications counts as the only measurement of patent activity. Future research should take into account a more detailed assessment of a variety of different quality indicators such as patent claim, patent citation, and patent family (IPC)... in order to propose a broader approach of patent signaling value.

Despite these limitations, our study contributes in several ways to the current understanding of signaling theory. First, to our knowledge, this is the first study that specifically investigates the signaling value of Japanese patent applications. Second, while previous works provided evidence on the signaling function of patents among start-ups in a limited number of industries, our work paints a more holistic view that encompasses all manufacturing companies across the entire industry sectors. Third, this research provides a new insight into the role of patents as an effective signal of firms' performance to IPO investors when there is information friction between the two parties. Fourth, we present fresh evidence that the effect of the patent signal on the outcome of an IPO is dependent on the technology intensity of the industry in which a company conducts business. While its benefit is negligible among High-tech companies, Low-tech firms profit greatly and enjoy an increased likelihood of attracting external financing through an IPO. Further research to clarify the limitations of this research and validate our findings could benefit the global scholarly community of economic researchers.

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