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Divergent effects of external financing on technology innovation activity: Korean evidence

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ABSTRACT

This paper explores a variety of effects of external financing subdivided into bank loans and bond and stock issues on the technology innovation activity (TIA) of Korean listed firms for the full sample period of 1st January 2000 to 31st December 2008. We find evidence that indirect external financing of bank loans makes a negative impact on TIA of the Korean firms whereas direct external financing of security issues does a positive one on it. The results support the hypothesis of manager discretion that banks' conservative lending criteria demanding considerable collaterals from firms discourage managers from an investment in TIA with high risk-high return while external financing via security issues grants managers more discretion for their TIA. This study building up the prior literature that primarily devote to an effect of internal financing on TIA of firms provides firm managers or academic researchers with valuable implications for evaluation of various impacts and roles of external financing in association with financing decisions for TIA of firms.

1. Introduction

Since outstanding academics of Schumpeter (1942) and Solow (1957) proposed that innovation is an essential factor for firm and economic growth in the country, the definition of innovation and factors to boost it within firms have been a primary concern to academics of innovation for the last decades. According to Becheikh et al. (2006), technological innovation is only referred to as innovation in products and process that are differentiated with organizational or administrative innovation. Such a definition on technological innovation is also well described in OECD (1997) below:

> "Technological product and process (TPP) innovations comprise implemented technologically new products and processes and significant technological improvements in products and processes. A TPP innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). TPP innovations involve a series of scientific, technological, organizational, financial and commercial activities. The TPP innovating firm is one that has implemented technologically new or significantly technologically improved products or processes during the period under review." (*Oslo Manual*, 1997, p. 31)

In association with internal and external factors of firms to accelerate their technological activities, studies of personnel and organizational management have explored those in a general nature, a culture, a geographical location, a networking of the firm and so on. Meanwhile, studies of corporate finance have tried to find the answer in financing sources. In general, financing to support technology innovation activity (TIA, hereafter) of firms is categorized into two sources of internal and external financing. Unanimously, several literature address that internal financing via retained earnings makes a positive impact on TIA of firms (e.g. Branch, 1974; Switzer, 1984; Himmelberg and Petersen, 1994; Brown, 2000; Hall, 2002; Beneito, 2003 among others). However, literature associated with a relation between external financing and TIA of firms report mixed results because the external financing of firms has various properties depending on its sources.

Specifically, external financing of a bank loan demands official information such as an investment plan and a financial status from firm managers whereas that of a securities (bond or stock) issue does not. Banks may alleviate not only managers' moral hazards but also agency problems

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between managers and creditors through a grading function *ex ante* and a monitoring role for their firms *ex post*. Banks make their decisions for loans for firms' projects with their loans criteria, which are usually established based on their past experiences and knowledge. The criteria may be considerably useful for routine projects of firms. However, for new and risky projects of firms beyond banks' experiences and knowledge, the criteria have a limitation that discourages managers who are willing to invest in innovative projects and even deters them from the projects themselves (Scherer, 1984; Rajan and Zingales, 2003). Dewatripont and Maskin (1995) also argue that banks are reluctant to flow their money into uncertain and risky TIA. Along a similar vein, Stulz (2001) argues that banks are inclined to be conservative in their lending decisions on risky projects of firms because they are under capital constraints such as a reserve fund for payment. Banks of relationship financing also tend to monitor subordinates related to research and development (R&D) tasks that lead TIA as well as a chief executive officer (CEO).

Meanwhile, CEOs who finance the capital needed for TIA via direct financing have larger managerial discretion (Baumol, 2001) in general. A remarkable study of Rajan and Zingales (2003) also address that indirect financing via bank loans is more effective to firm managers focusing routine projects whereas direct financing of security issues is more beneficiary to managers seeking for innovative technological activities as it gives them greater discretion for an investment decision on TIA. Moreover, the latter has a merit that strongly inspires managers to invest in TIA with great potential although the TIA is uncertain and risky since they are free from a rejection of a loan or a reloan from banks. The theoretical or conceptual discussions above imply a possibility that the impact of external financing on TIA of firms could be differentiated by its sources in an empirical perspective as well. Unfortunately, the previous studies targeting firms in advanced countries such as Germany, the UK and the US mostly explore the effects of internal finance on TIA although they do an effect of equity external financing on it. So, to fill up the lacuna to the literature, our study aims to examine various effects of external financing subdivided into three different types of bank loans, bond and stock issues on TIA proxied by R&D expenditures of firms in Korea, one of leading emerging economies. A significant body of studies in innovation management and economics has commonly used the R&D expenditures as a feasible proxy for the innovative technological activity of firms. In practice, private firms' R&D expenditures also represent an input for creating their sustainable profits in an innovative production function as an effort of firms seeking for technological innovation (e.g., Grabowski and Mueller, 1978; Ben-Zion, 1984; Griliches, 1986; Chauvin and Hirschey, 1993; Cohen et al., 1987; Bosworth and Rogers, 2001; Hirschey and Weygandt, 1985; Toivanen et al., 2002 among others).

In general, firms in high tech industries may be lagged behind rivals without R&D investments for the development of new technology and products due to a fast innovation speed in their field. So, they are inclined to further invest their efforts for the development of a high technology. In such a vein, by subdividing the full sample into high and non-high tech firm groups, we also explore a difference for the impacts of the three types of external financing on TIA. In addition, to account for uniqueness of the *chaebol* oriented Korean economy, we also examine whether there is a difference between *chaebol* affiliated firms and non-*chaebol* affiliated firms for effects of various external financing on TIA. Many of the Korean firms belong to a business group known as *chaebols*.[1] This property of Korean *chaebol* affiliated firms may enable us to draw insightful implications for relationship between external financing and Korean firms' TIA.

Principal findings from our study are: this paper indicates evidence that external financing via bank loans makes a negative impact on TIA of Korean listed firms whereas the financing via security (bond or stock) issues does a positive one on it. The results support the hypothesis of manager discretion that banks' conservative lending criteria which demand considerable collaterals from firms discourage managers from investments in TIA with high risk-high return. Meanwhile, external financing of security issues grants managers discretion for their TIA. Regarding the subsamples, external financing of security issues makes no effect on TIA of high tech group firms and that of bank loans does no effect on TIA of *chaebol* affiliated firms.

This paper is structured as follows. Section 2 reviews the previous literature. Section 3 describes data issues for this study. Section 4 specifies a research model and hypotheses. Section 5 discusses empirical results. The conclusion is in Section 6.

2. Literature

External financing of a bank loan demands official information such as an investment plan and a financial status from firm managers whereas that of a securities (bond or stock) issue does not. Banks may alleviate not only managers' moral hazards but also agency problems between managers and creditors through a grading function *ex ante* and a monitoring role for their firms *ex post*. Banks make their decisions for loans for firms' projects with their loans criteria, which are usually established based on their past experiences and knowledge. The criteria may be considerably useful for routine projects of firms.

However, for new and risky projects of firms beyond banks' experiences and knowledge, the criteria have a limitation that discourages managers who are willing to invest in innovative projects and even deters them from the projects themselves (Scherer, 1984; Rajan and Zingales, 2003). Dewatripont and Maskin (1995) also argue that banks are reluctant to flow their money into uncertain and risky TIA. Along a similar vein, Stulz (2001) argues that banks are inclined to be conservative in their lending decisions on risky projects of firms because they are under capital constraints such as a reserve fund for payment. Banks of relationship financing also tend to monitor subordinates related to research and development (R&D) tasks that lead TIA as well as a chief executive officer (CEO).

Meanwhile, CEOs who finance the capital needed for TIA via direct financing have larger managerial discretion (Baumol, 2001) in general. A remarkable study of Rajan and Zingales (2003) also address that indirect financing via bank loans is more effective to firm managers focusing routine projects whereas direct financing of security issues is more beneficiary to managers seeking for innovative technological activities as it gives them greater discretion for an investment decision on TIA. Moreover, the latter has a merit that strongly inspires managers to invest in TIA with great potential although the TIA is uncertain and risky since they are free from a rejection of a loan or a reloan from banks. The theoretical or conceptual discussions above imply a possibility that the impact of external financing on TIA of firms could be differentiated by its sources in an empirical perspective as well.

Regarding the empirical studies for the issue, Hall (1990) and Bhagat and Welch (1995) targeting USA firms report evidence that an increase in leverage ratio in the previous fiscal year, due to an external financing activity, decreases R&D expenditures of firms in the fiscal year. On the other hand, the recent study of Brown and Petersen (2011) address that debt issues of US manufacturing firms make no significant effects on R&D investments of firms but instead, internal liquidities (i.e., cash holding) in firms are a crucial factors for increasing the R&D efforts of firms. By contrast, Bhagat and Welch (1995) suggest that TIA and leverage of firms have a positive relationship. In the recent time, Muller and Zimmermann (2009) find that equity external financing has a positive influence on R&D activities of innovative firms in Germany particularly.

[1] The Korean *chaebols* have many affiliates tied by a nexus of explicit and implicit contracts and connected by an extensive arrangement of reciprocal shareholding agreements under its wing (Baek et al., 2006). Korean *chaebols* are often compared to Japanese *keiretsus* with many similarities wing. However, the most distinction between Korean *chaebol* and Japanese *keiretsus* is if they have families in control. That is, the former has such families but the latter has never had them after the World War II. Korean *chaebol* affiliates make decisions for investment and financing decisions and for an allocation of funds to serve group-level purposes and thus create an explicit internal capital market (Bae et al., 2011). In addition, compared to non-*chaebol* affiliated firms, *chaebol* affiliated firms also enjoy a further advantageous position for various external financing due to higher collaterals and credit ratings in the Korean economy (Kim et al., 2004). See Cazurra (2006) for the comprehensive review on various business groups in the world economy.

In a similar vein, Brown et al. (2009) report evidence of very clear differences between mature and young firms for effects of external equity finance on US firms' R&D activities. In their panel analysis, the point estimates for mature firms are economically and statistically meaningless for not only external financing variables but also internal ones whereas those for young firms are economically and statistically significant for both. Previous literature on the relationship between innovation and banks (one of external financing) is also sparse. Among others, Benfratello et al. (2008) suggest an importance of regional banking development for innovation performance of Italian firms doing business in the regions. The authors address that the number of bank branches relative to the population in a region makes a positive influence on the possibility to introduce an innovation of firms in the regions. Another strand of the literature is to use micro-data on individual bank-firm pairs and their relationship based on credit. For instance, Herrera and Minetti (2007) suggest that innovation is more likely to occur when firms build long last relationships with firms. Haselmann et al. (2009) report evidence that firms' innovation is more active when their main bank is based on a private bank system.

Despite the studies above, by subdividing external financing into bank loans, bond and stock issues, studies that comprehensively investigate its various impacts on TIA are still scarce. Very exceptionally, a recent study of Atanassov et al. (2007) analyzes various impacts of external financing subdivided into the three types on the number of patents proxied for TIA. The authors indicate empirical evidence that external financing of bond or stock issues significantly contribute to a boost in TIA of firms while that of bank loans does not. Strictly speaking, the number of patents, an outcome of TIA, is not a proxy for TIA but one for an invention. In addition, because of much different numbers of patents across industries and keeping of industrial secrets and lead time against rivals, firms have intrinsic limitations not to apply for all patents (Michie, 1998; Kleinknecht et al., 2002). As mentioned earlier, most of the existing studies heavily deal with the relationship between innovation and finance. Given TIA as a cornerstone for growth and competitive advantages for firms and economy in every country, this topic should be seriously investigated for firms in emerging economies where have been urgent for economic growth and made a significant role for growth in the world economy. However, the studies targeting firms in emerging economies are limited to very few in international academic circles.

3. Sample data

Our study targets Korean firms listed on two Korean stock markets - Korean Stock Price Index (KOSPI) and Korean Securities Dealers Quotations (KOSDAQ) markets, for the full sample period of 1st January 2000 to 31st December 2008. For a matter of a rigorous study, we filter them by the following criteria.

- Exclude firms with which information of R&D expenditures is unavailable from Korean Information Service (KIS) Value Library for the full sample period.
- Exclude financial institutes such as bank, securities, insurance, where capital structure, business model and public regulation are quite different from those of manufacturing firms.
- Exclude firms that financial data are unavailable from the database sources of Korea Financial Investment Association Bond Information System (KOFIA BIS) and KIS Value over the full sample period.
- Exclude firms controlled by creditors and acquisitioned by other firms for the consistency of financial data.

Table 1
The full sample firms by year.
This table shows the full sample firms fulfilling the selection criteria yearly. We follow up the classification criterion of Hall et al. (2005) for a classification between the groups of high tech and non-high tech firms. For the classification between the groups of *chaebol* affiliated firms and non-*chaebol* ones, we use the classification provided by the Korea Fair Trade Commission.

Year	Sample firms	Classification by high technology		Classification by *Chaebol* affiliation	
		High tech firms	Non-high tech firms	*Chaebol* affiliated firms	Non-*Chaebol* affiliated firms
2000	556	97	459	151	405
2001	573	100	473	157	416
2002	584	98	486	165	419
2003	597	103	494	169	428
2004	602	104	498	172	430
2005	604	104	500	173	431
2006	610	104	506	173	437
2007	621	106	515	176	445
2008	624	104	520	179	445
Total	5371	920	4451	1515	3856

The final sample firms fulfilling the selection criteria are yearly given in Table 1. The sample number of panel data across firm and year is 5371 consisting of unbalanced panel data sets. Following up a classification of Hall et al. (2005), we categorize firms in industries of pharmacy, medicine and precision, computer equipment, telecommunication, aviation, and aerospace into firms of a high tech industry and remaining firms into ones of a non-high tech industry, respectively. To take into account the specialty of the *chaebol*-oriented Korean economy, this study also partitions the full samples into groups of *chaebol* affiliated firms and non-*chaebol* affiliated firms. To this end, we follow up the classification which the Korea Fair Trade Commission (KFTC) announces every April. The KFTC classification, which is the most commonly used for the classification for large business groups in Korea, is based on the size of gross total assets at a business group level. In this study, any firms where have ever been appointed as the group of large firms or mutual investment restriction firms are categorized into the group of *chaebol* affiliated firms.[2] Through the classification, in Table 1, the number (920) of firms in high tech industries is way smaller than that (4451) of firms in non-high tech industries. As for the *chaebo*l affiliation, 1515 firms are in the *chaebol* affiliated firms group but 3856 firms are in the non-*chaebol* one.

4. Research model, measurement of variables and hypotheses

This section discusses a research model, a measurement of variables, and principal hypotheses to examine a variety of impacts of external financing on TIA of Korean listed firms.

4.1. Research model

We extend the regression model of Bhagat and Welch (1995), where use an aggregate leverage as a proxy for external financing. Specifically, our study decomposes external financing into bank loans, bond and stock issues and analyzes the respective impacts of the three types of external

[2] The KFTC defines the mutual investment restriction firms as affiliates within the same business group, where total assets are more than 5 trillion won.

financing on TIA. To this end, this study employs panel data techniques which allow us to effectively control for unobserved heterogeneity and cross sectional dependence problems across cross sectional and time series units. The panel data regression model estimated in this study is

$$rd_{it} = \alpha_0 + \beta_1 bank_{it} + \beta_2 bond_{it} + \beta_3 seo_{it} + \beta_4 fcf_{it} + \beta_5 size_{it} + \beta_6 q_{it} + \sum_{y=1}^{9} yd + \delta_i + \varepsilon_{it} \quad (1)$$

where, rd_{it}: TIA of firm i at the year t
$bank_{it}$: change in remaining bank loans of firm i at the end of the year t
$bond_{it}$: sum of public bond issues of firm i at the year t
seo_{it}: seasonal equity offerings of firm i at the year t
fcf_{it}: free cash flows of firm i at the year t
$size_{it}$: the number of employees of firm i at the year t
q_{it}: Tobin's Q of firm i at the year t
yd: year dummies over the full sample periods (9 years)
δ_i: time invariant and unobserved panel effects (fixed or random effect)
ε_{it}: time variant error terms

4.2. Measurement of each variable and hypotheses

4.2.1. Dependent Variable

In the panel regression model above, the dependent variable of rd_{it}, a proxy for TIA, is a R&D expenditure measured in a decimal unit by

$$= \frac{\sum capitalized\ and\ \exp ensed\ R\&D\ investment\ at\ the\ end\ of\ fiscal\ year\ t}{capital\ stock\ at\ end\ of\ the\ previous\ fiscal\ year\ t\text{-}1} \quad (2)$$

4.2.2. Exogenous Explanatory variables

First of all, $bank_{it}$, a proxy for an indirect external financing, is measured by

$$= \frac{\{(the\ remaining\ balance\ of\ bank\ loans\ at\ the\ end\ of\ the\ fiscal\ year\ t) - (\ the\ remaining\ balance\ of\ bank\ loans\ at\ the\ end\ of\ the\ previous\ fiscal\ year\ t\text{-}1)\}}{the\ capital\ stock\ at\ the\ end\ of\ the\ fiscal\ year\ t.} \quad (3)$$

When banks lend money for TIA of firms, they generally require not only informal information of a financial statement and an investment of firms but also a fulfillment of loans criteria based on their experiences and knowledge. For routine and typical projects of firms, the criteria could be quite useful for a speedy and reasonable decision making. However, for evaluating technological projects beyond their experiences and knowledge, this may discourage managers' zeal to invest in innovative projects or make them deter the project itself (Scherer, 1984; Rajan and Zingales, 2003 among others). In addition, due to the conservativeness of bank loan, banks are inclined to be reluctant to supply money for high risky and uncertain R&D activity of firms and so, may make a negative influence on TIA of firms (Dewatripont and Maskin, 1995; Stulz, 2001). Lastly, in a perspective of discretion of managers who lead TIA, banks may be also inclined to monitor subordinates related to TIA as they heavily monitor CEOs who direct it (Baumol, 2001). Along the same vein, Atanassov et al. (2007) analyzes various impacts of a variety of external financing for firms' TIA. They address that external financing of bank loans also leads to a decline in TIA of firms. Based on the discussions above, we set up the following research hypothesis.

Hypothesis 1. *External financing of bank loans makes a negative impact on TIA.*

With regard to the other explanatory variables, $bond_{it}$ and seo_{it}, which are direct external financing, are measured by

$$= \frac{public\ bond\ issues\ of\ firms\ at\ the\ end\ of\ the\ fiscal\ year\ t}{capital\ stock\ at\ the\ end\ of\ the\ previous\ fiscal\ year\ t\text{-}1} \quad (4)$$

and

$$= \frac{total\ seasonal\ equity\ offerings}{capital\ stock\ at\ the\ end\ of\ the\ fiscal\ year\ t}, \text{ respectively}$$

The former is a proxy for external financing of bond issues and the latter is one for external financing of stock issues. External financing of securities (bond or stock) issues, which directly finances capital for TIA of firms in capital markets, provides subordinates as well as CEOs with greater discretion for their TIA than that of bank loans (Baumol, 2001). An outstanding study of Rajan and Zingales (2003) argues that in association with effective managerial discretion for TIA of firms, external financing of security issues is more advantageous than that of bank loans. Moreover, because external financing of security issues frees managers from anxiety of (re) loans refusal from banks, it is more useful for inspiring a strong zeal for TIA with high risk but great potential. Atanassov et al. (2007) suggest that external financing via security issues gives managers a strong incentive to seek for uncertain and risky TIA because it empowers them discretion for TIA. In particular, an interesting study of Carpenter and Petersen (2002) focuses on the effect of external financing of stock issues on firms' R&D efforts for their substantial growth. Specially, using an unbalance panel of very R&D intensive and publicly traded, US firms, they present evidence that new equity financing such as IPO (initial public offerings) is a very important source of financing for firms' growth via the success in the R&D projects, compared to internal financing. Similarly, Muller and Zimmermann (2009) present that the kind financing of stock issue lead to a positive effect for German firms' R&D investments. In association with the effect of external financing of bond issue, empirical studies by Bhagat and Welch (1995)and Atanassov et al. (2007) suggest that firms' debts via bond issues contribute to an significant boost in TIA of firms. The discussions so far allow us to set up the following research hypotheses to examine the impacts of external financing of security issues on TIA.

Hypothesis 2. *External financing of security issues make a positive impact on TIA.*

Hypothesis 2-2. *External financing of stock issues is positively associated with TIA.*

Hypothesis 2-1. *External financing of bond issues is positively associated with TIA.*

Note that the units of the three explanatory variables are expressed in decimal units to match with that of the dependent variable.

4.2.3. Control variables

In order to control firm characteristics that may be influential on TIA, we use three control variables; free cash flows (fcf_{it}), future growth opportunities (q_{it}), and firm size ($size_{it}$). First, fcf_{it} is measured by

$$= \frac{\textit{free cash flows of firm at the year } t}{\textit{capital stock at the end of the fiscal year } t} \tag{5}$$

This variable reflects information about internal financing of the firms. Because the internal financing proxied by fcf_{it} for TIA may make free managers from a default risk and a threat to management without serious financial constraints, it may provide managers with drivers that they can concentrate on TIA. Thus, we expect a positive impact of free cash flows (fcf_{it}) on TIA. In reality, several studies of innovation report a positive effect of this variable on TIA(e.g., Himmelberg and Petersen, 1994; Brown, 2000; Beneito, 2003 among others). For firm size ($size_{it}$), we following up previous innovation studies that employ the number of employees (e.g., Giunta and Trivieri, 2007; Svensson, 2013 among others).[3] The specific measure for is like Eq. (6)

$$= \frac{\textit{the number of the employees at the year } t}{\textit{average employee numbers of sample firm at the fiscal year } t} \tag{6}$$

This variable reflecting information about firm size is expected to be positive with rd_{it}. For example, Atanassov et al. targeting USA firms find empirical evidence that the firm size makes a positive impact on the innovative technological activity of the firms. Lastly, theoretically, the measurement of q_{it}, a proxy for future growth opportunities of a firm, is by

$$= \frac{\textit{market value of assets}}{\textit{by substitute value of assets at the end of the fiscal year } t} \tag{7}$$

However, due to unreality of exact substitute value of total assets, following up Kaplan and Zingales (1997) and Kim et al. (2011), we measure q_{it} as Eq.(8)

$$= \frac{\textit{market value of assets (i.e. book value of liabilities + market value of equity capital)}}{\textit{book value of assets ((i.e. book value of liabilities + book value of equity capital) at the end of the year } t} \tag{8}$$

This variable is expected to be positive with TIA based on Atanassov et al. (2007) suggesting its positive impact on TIA (R&D) of USA firms. Lastly, we use year dummies to strictly account for time varying nature correlated with R&D investments over the full sample periods (9 years). This takes value 1for each year over the full sample periods and value 0 otherwise, respectively. The whole control variable above is also expressed in a decimal unit matching like the dependent and explanatory variables.

Given that the cross sectional dimension (N) and the time series dimension (T) are 629 and 9, respectively, the exact number of our panel data sets should be, in principle, 5661 ($N \times T$). However, the final number of panel data used in this study is unbalanced 5371 across cross sectional units over time, due to a data missing by the data filtering criteria.

5. Empirical results

5.1. Descriptive statistics

Table 2 indicates descriptive statistics of the variables. rd_{it} of the full sample firms shows a mean of 1.0%. The negative minimum (−5.729) of $bank_{it}$ having the mean of 0.3% would be due to repayments of bank loan. $bond_{it}$ and seo_{it} have a mean of 1.0% and 1.9%, respectively. Standard deviations for control variables of fcf_{it},$size_{it}$, and, q_{it} are high more or less due to a substantial difference between a maximum and a minimum.

5.2. Correlation analysis across the characteristic variables of the sample firms

Before actual panel regressions, we test for a correlation across the characteristic variables of the sample firms to check a possibility of multicollinearity across them. Table 3 shows, overall, little Pearson correlation coefficients for all the pairs between the variables. This suggests no serious multicollinearity across the variables for our rigorous panel analysis. The statistically significant coefficients for most pairs justify the linear assumption for our regression model to examine linear links between the dependent variable and explanatory variables of interest. Exceptionally, the insignificant estimates (−0.004) between the dependent variable rd_{it} and the explanatory variable $bank_{it}$ associated with external financing via banking could imply one possibility of a partial existence of a nonlinear relation between both. So, we supplement a diagnostic analysis for whether this kind of external financing make a nonlinear effect on TIA of our sample firms.

5.3. Relationship between various forms of external financing and TIA

This subsection investigates specific impacts of the external financing on the technology innovation activity (rd_{it}) of Korean listed firms. Table 4 shows the baseline results obtained from panel regressions

[3] $bank_{it}$,$bond_{it}$ and seo_{it}, may have high correlation coefficients with total assets as well as sales. To overcome any possible multicollinearity across the variables, we use the number of employees, one of popular proxies for the firm size, instead of sales or total assets.

Table 2
Descriptive statistics on all the variables.
This table indicates descriptive statistics for each variable. The sample consists of 5371 firm-year observations for the full sample period 2000–2008. rd_{it}, a proxy of TIA, is measured by the sum of capitalized and expensed R&D investment at the fiscal year t divided by capital stock at the end of the previous fiscal year t-1. $bank_{it}$ is measured by (the balance of bank loans at the end of the fiscal year t) - (the balance of bank loans at the end of previous fiscal year t-1)] divided by (capital stock at the end of the fiscal year). $bond_{it}$ is measured by public bond issues of firms divided by capital stock at the end of the previous fiscal year t-1 and seo_{it} is measured by total SEO divided by capital stock at the end of the year t. fcf_{it} is measured by free cash flows of firms divided by capital stock at the end of the fiscal year t. $size_{it}$ is measured by the number of employees divided by average employee numbers of sample firms at the end of the year t. q_{it} is measured by market value of assets divided by book value of assets at the end of the fiscal year *t*.

Variables	Mean	Std. Dev.	Maximum	Minimum
rd_{it}	0.010	0.021	0.368	0.000
$bank_{it}$	0.003	0.158	5.423	−5.729
$bond_{it}$	0.010	0.041	1.898	0.000
seo_{it}	0.019	0.111	3.764	0.000
fcf_{it}	0.019	0.373	13.569	−14.937
$size_{it}$	1.002	3.326	59.937	0.001
q_{it}	0.952	0.604	20.544	0.013

for this. First of all, for desirable panel data analyses, all Lagrange - Multiplier (*LM*) statistics (8173.56, 8184.90, 8240.84, and 8276.56) of Breusch and Pagan (1980) in Table 4 reject the null of no panel effect for each panel model as the *LM* statistics distributed as chi-squared with 1 degree of freedom far exceed the 95% significance level. This suggests an existence of a time invariant individual (panel) effect on the panel regression models. In addition, Hausman statistics (63.64, 73.37, 88.87, and 81.67) far exceeding the critical value (11. 07) at the 5% level reject the null that FE estimator equals RE estimator. This suggests that panel data models with fixed effects (FE) are preferred to ones with random effects (RE). Based on the discussions, the results in Table 4 are from panel data regressions with fixed effects.

Specifically, Regression 1 indicates a highly significant negative coefficient (−0.0039) for $bank_{it}$ at the 1% level, which suggests that external financing of bank loans makes a negative impact on TIA of Korean listed firms. A possible explanation for this would be due to a possibility that a bank may discourage managers from their TIA because it is usually reluctant to lend money on risky and uncertain projects. In a perspective of manager discretion, this finding is line with Baumol (2001) that subordinates related to R&D are also inclined to be monitored by the bank given that banks intensively monitor CEOs. This is also consistent with Rajan and Zingales (2003) that relationship financing with banks is an optimal choice to firms seeking for certain and structured projects. Meanwhile, Atanassov et al. (2007) report that bank financing of firms does not contribute to an increase in their TIA. Accordingly, the result associated with $Bank_{it}$ supports our 1st hypothesis that external financing via bank loans is negatively associated with TIA of firms. Regarding

Table 4
Baseline results of panel regressions of external financing on TIA.
The full sample consists of panel data of 5371 firm-year observations for the full sample period 2000–2008. *** denotes significance at the 1% level. Figures in parenthesis are *t*-statistics.

Variables	Regression 1	Regression 2	Regression 3	Regression 4
constant	0.0074***	0.0075***	0.0080***	0.0076***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
$bank_{it}$	−0.0039***			−0.0027***
	(0.0009)			(0.0009)
$bond_{it}^2$		0.0241***		0.0145***
		(0.0041)		(0.0043)
seo_{it}			0.0154***	0.0132***
			(0.0016)	(0.0017)
fcf_{it}	0.0032***	0.0027***	0.0041***	0.0041***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
$size_{it}$	0.0008***	0.0008***	0.0008***	0.0008***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
q_{it}	0.0019***	0.0014***	0.0009***	0.0011***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
year dummy	Inclusive	Inclusive	Inclusive	Inclusive
Observations	5371	5371	5371	5371
R^2	0.106	0.101	0.098	0.101
LM statistics(x_1^2)	8173.56***	8184.90***	8240.84***	8276.59***
Hausman statistics (x_k^2)	63.64***	73.37***	88.87***	81.67***

control variables in Regression 1, first, the highly significant positive coefficient (0.0032) of fcf_{it} suggests that internal financing is positively associated with TIA because it frees managers from financing constraints for TIA. Both $size_{it}$ and q_{it} show highly significant positive coefficients (0.0008, 0.0019). These suggest that firm size and future growth opportunities of firms make positive effects on their TIA.

On the contrary, Regression 2 and 3 indicate highly significant positive coefficients (0.0241, 0.0154) for $bond_{it}$ and seo_{it}, respectively, at the 1% level. This suggests that external financing of security issues, which are direct financing methods, are positively associated with TIA of the Korean firms. Unlike the result of external financing of bank loan, the results support our hypotheses that external financing via bond or stock issues makes a positive impact on TIA because such a financing method gives managers much discretion for risky projects of TIA. This is in accordance with Rajan and Zingales (2003) and Atanassov et al. (2007) who argue that this kind of external financing provides managers with more discretion to invest sources of their firms in innovative activities. Results for the control variables in Regression 2 and 3 are qualitatively similar with those in Regression 1 discussed already. Moreover, all the results of Regression 4 including every variable, which are qualitatively identical to those in Regression 1, 2, and 3 for each variable, strongly confirm our findings discussed so far as well.

By dividing the full sample with the two criteria of the high technology and the *chaebol* affiliation of the sample firms, this paper also

Table 3
Pearson correlation matrix across the whole variable.
This table indicates Pearson correlation coefficients with significance levels across all the variables. The full sample consists of 5371 firm-year observations for the full sample period 2000–2008. ***denotes significance at the 1% level. Figures in parenthesis are p-values.

Variables	rd_{it}	$bank_{it}$	$bond_{it}$	seo_{it}	fcf_{it}	$size_{it}$	q_{it}
rd_{it}	1.0000						
$bank_{it}$	−0.004	1.000					
	(0.752)						
$bond_{it}$	0.073***	0.017	1.000				
	(0.000)	(0.222)					
seo_{it}	0.074***	−0.140***	0.218***	1.000			
	(0.000)	(0.000)	(0.000)				
fcf_{it}	0.069***	0.235***	0.060***	−0.283***	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)			
$size_{it}$	0.270***	−0.001***	0.076***	−0.039***	0.012	1.000	
	(0.000)	(0.966)	(0.000)	(0005)	(0.377)		
q_{it}	0.222***	0.185***	0.119***	0.244***	0.153***	0.084***	1.000
	(0.000)	(0.000)	(0.000)	(0000)	(0.000)	(0.000)	

explores how the impacts of a variety of external financing on TIA of the Korean firms vary across subsamples. Specific results for this are given in Table 5. First, Panel A showing regression results for groups divided by the high technology criterion suggests that not only the three types of external financing ($bank_{it}$, $bond_{it}$ and seo_{it}) but also the internal financing (fcf_{it}) make no significant effect for TIA of firms of the high tech group. This striking result is due to a nature of high-tech firms. That is, firms categorized in the high tech group have an exigent driver to keep their TIA to make future great profits for survival and growth regardless of approaches to finance it. Thus, this may lead to a weakening of the relation between their TIA and financing factors. Firm size ($size_{it}$) makes a marginally positive impact on TIA whereas future growth opportunities (q_{it}) do a significantly positive one on it.

However, empirical results for non-high tech firm group in Panel A of Table 5 make a different story. External financing of bank loans ($bank_{it}$) has a highly significant negative influence on TIA at the 1% level but the other external financing of $bank_{it}$ and seo_{it} make a significant positive one on it at the same level. These could be explained by managers' zeal that wishes to conduct TIA of firms without any monitors by loan lenders such as banks. TIA of non-high tech firms makes significant positive relation with size ($size_{it}$) like the case of high tech firms, but does no significant one with their future growth opportunities (q_{it}).

Panel B presents results of the panel regressions for subsample groups spilt by the *chaebol* affiliation criterion related to the uniqueness of the Korean economy. It is analyzed that there exist, overall, a substantial difference across groups of *chaebol* affiliated firms and non-*chaebol* affiliated ones in association with the impacts of external financing on TIA of Korean listed firms. Specifically, for firms categorized in a *chaebol* affiliates group, the external financing of $bank_{it}$ has no significant relation with TIA (rd_{it}). This result would be due to a merit of great collateral capacity of *chaebol* affiliates that enable them to easily finance from financial institutes. So, we suggest that this kind of external financing makes neutral influence on TIA of the *chaebol* affiliates group. The great collateral capacity of *chaebol* affiliates may make it the financing of bond issues to incur a negative impact on their TIA because relationship financing with banks could be a more convenient and useful method for financing via collaterals. Along the same vein, the $bond_{it}$ variable for the *chaebol* affiliates group that shows a negative coefficient (−0.0111) confirms this.

In the case of the group of non-*chaebol* affiliated firms, TIA has a negative relation with external financing of bank loans ($bank_{it}$) but a positive one with that of $bond_{it}$ and seo_{it}. Because non-*chaebol* affiliated firms relatively lack for collaterals, banks' conservative criteria to evaluate firms' projects may reduce managers' will for innovative technological activity and even deter them from it. However, the external financing of stock and bond issues provides managers with more discretion for TIA due to the freedom from a rejection of a loan or a reloan from banks. Control variables of cash flows (fcf_{it}) and firm size ($size_{it}$), and future growth opportunities (q_{it}) show positive relations with TIA (rd_{it}), respectively, like those in Table 4 for the full sample.

Table 5
Panel regression results for the subsamples.

Variables	Panel A		Panel B	
	High tech firms	Non-high tech firms	*Chaebol* affiliated firms	Non-*Chaebol* affiliated firms
constant	0.0181***	0.0051***	0.0092***	0.0030***
	(0.0015)	(0.0013)	(0.0012)	(0.0011)
$bank_{it}$	−0.0011	−0.0021***	−0.0022	−0.0030***
	(0.0030)	(0.0009)	(0.0031)	(0.0010)
$bond_{it}$	0.0050	0.0120***	−0.0111**	0.0290***
	(0.0161)	(0.0043)	(0.0051)	(0.006)
seo_{it}	0.0024	0.0191***	0.0223***	0.0110***
	(0.0041)	(0.0013)	(0.0046)	(0.0012)
fcf_{it}	−0.0030	0.0050***	0.0222***	0.0040***
	(0.0020)	(0.0004)	(0.0008)	(0.0013)
$size_{it}$	0.0005	0.0005*	0.0007***	0.0081***
	(0.0004)	(0.0003)	(0.0001)	(0.0013)
q_{it}	0.0031***	−0.0002	−0.0011*	0.0012***
	(0.0012)	(0.0003)	(0.00061)	(0.0005)
year dummy	Inclusive	Inclusive	Inclusive	Inclusive
Obs.	920	4451	1515	3856
Firms	106	523	181	449
F-value	7.34***	21.31***	4.61***	16.74***
	(<1%)	(<1%)	(<1%)	(<1%)
R^2	0.158	0.071	0.158	0.027
LM statistics (x_1^2)	1281.57***	5402.51***	2744.33***	5306.48***
	(<1%)	(<1%)	(<1%)	(<1%)
Hausman statistics (x_k^2)	1211.83***	22.49***	23.23***	57.96***
	(<1%)	(<1%)	(<5%)	(<1%)

5.4. Diagnostic test

5.4.1. CSD across error terms in the panel model

Several literature related to the panel data analysis present evidence that panel data sets embrace the substantial cross sectional dependence (CSD) between error terms in the panel model (see Robertson and Symons, 2000; Pesaran, 2004; Baltagi, 2005 among others). Those studies address that the CSD problem in a panel model may rise due to a presence of common shocks and unobserved components as well as idiosyncratic dependence in the disturbances.

To effectively overcome the CSD problem in a panel data analysis, the fixed effects-panel regression with the Driscoll and Kraay standard errors may be a good alternative. By running a Monte Carlo simulation, Driscoll and Kraay (1998) and Hoechle (2007) compare the finite sample properties of CSD – consistent Driscoll-Kraay estimator with the properties of others, more commonly used covariance matrix estimators of residuals not accounting for CSD. Importantly, both papers report that Driscoll-Kraay standard errors are well calibrated although a cross sectional correlation across panel data sets is present. Hence, our study runs the FE panel regression with the Driscoll-Kraay standard errors to account for the CSD. Table 6 reports the results obtained by this test for the full sample. Overall, it could be said that the results by the FE panel regressions with the Driscoll-Kraay standard errors in Table 6 are qualitatively similar with those by the common FE panel regressions for the full sample discussed. An only exception is on the control variable related to firms' future growth opportunities (q_{it}) in Regression 3 and 4.

Table 6
Results of FE panel regressions with Driscoll-Kraay standard errors.
The full sample consists of panel data of 5371 firm-year observations for the full sample period 2000–2008. For our selection of the time lag (4), we apply a simple Heuristic from Plug-In Procedure of Newey-West. The Heuristic set $m(T) = floor[4(T/100)^{2/9}]$.***,**, and * denote significance at the 1%, 5%, and 10% levels, respectively. Figures in parenthesis are Driscoll-Kraay standard errors.

Variables	Regression 1	Regression 2	Regression 3	Regression 4
constant	0.0074***	0.0075***	0.0080***	0.0076***
	(0.0010)	(0.0011)	(0.0010)	(0.0009)
$bank_{it}$	−0.0039**			−0.0027*
	(0.0022)			(0.0017)
$bond_{it}$		0.0241**		0.0145**
		(0.0087)		(0.0070)
seo_{it}			0.0154***	0.0132***
			(0.0027)	(0.0034)
fcf_{it}	0.0032***	0.0027**	0.0041***	0.0041***
	(0.0010)	(0.0010)	(0.0008)	(0.0011)
$size_{it}$	0.0008***	0.0008***	0.00085***	0.0008***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
q_{it}	0.0019***	0.0014**	0.0009	0.0011**
	(0.0007)	(0.0007)	(0.0007)	(0.0005)
year dummy	Inclusive	Inclusive	Inclusive	Inclusive
Observations	5371	5371	5371	5371
R^2	0.023	0.027	0.038	0.042

Table 7
Results of the nonlinearity test for between TIA and the banking variable.
The full sample consists of panel data of 5371 firm-year observations for the full sample period 2000–2008. *** denotes significance at the 1% level. Figures in parenthesis are standard errors.

Variables	Regression 1	Regression 2	Regression 3	Regression 4
constant	0.0059***	0.0058***	0.0065***	0.0056***
	(0.0005)	(0.0005)	(0.0005)	(0. 0008)
$bank_{it}$	−0.0044***	−0.0042***	−0.0030***	−0.0035***
	(0.0009)	(0.0009)	(0.0009)	(0.0009)
$bank_{it}^2$	0.0013***	0.0013***	0.0011***	0.0012***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
$bond_{it}$		0.0237***		0.0149***
		(0.0041)		(0.0042)
seo_{it}			0.0145***	0.125***
			(0.0016)	(0.0017)
fcf_{it}	0.0033***	0.0032***	0.0044***	0.0042***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
$size_{it}$	0.0008***	0.0008***	0.0008***	0.0013***
	(0.0002)	(0.0002)	(0.0002)	(0.0001)
q_{it}	0.0021***	0.0018***	0.0012***	0.0016***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
year dummy	Inclusive	Inclusive	Inclusive	Inclusive
Observations	5371	5371	5371	5371
R^2	0.105	0.103	0.101	0.107
Hausman statistics (x_k^2)	127.52	145.50***	333.45***	−372
	(<1%)	(<1%)	(<1%)	(>10%)

5.4.2. A nonlinear effect of the external financing of banking on TIA

Previously we checked one possibility of a partial existence of nonlinearity between TIA of our sample firms and the external financing of banking in Table 3. For another diagnostic issue, this subsection tests for the nonlinear effects of the external financing of banking on TIA. For this, we run the whole regression, simultaneously incorporating both the bank variable and its square into the regression models.

The specific results for this are reported in Table 7. The results shown in Table are fundamentally similar with our baseline results in Table 4 above. Interestingly and surprisingly, all the regressions estimate the statistically negative coefficients at the 1% significance level for a transformation of the squared bank variable ($bond_{it}^2$) of interest. The dramatically changed results for this variable should reflect evidence of nonlinearity between TIA and external financing of banking. So, the results suggesting a positive relation between both imply that if mangers can access to very plenty of external financing of banking for TIA, they are willing to finance via banks for TIA although their managerial discretion could be partially victimized.

Table 8
Results of the endogeneity bias test.
The full sample consists of panel data of 5371 firm-year observations for the full sample period 2000–2008. For this test, the instrumental variables (IV) are the 1st lag of explanatory variables of $bank_{it}$, $bond_{it}$ and seo_{it}. *** and ** denote significance at the 1% and 5% levels, respectively. Figures in parenthesis are standard errors.

Variables	Regression 1	Regression 2	Regression 3	Regression 4
constant	0.0080***	0.0082***	0.0085***	0.0081***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
$bank_{it}$	−0.0034***			−0.0025***
	(0.0010)			(0.0010)
$bond_{it}$		0.0251***		0.0165***
		(0.0041)		(0.0043)
seo_{it}			0.0138***	0.0109***
			(0.0017)	(0.0018)
fcf_{it}	0.0042***	0.0035***	0.0041***	0.0042***
	(0.0006)	(0.0006)	(0.0006)	(0.0006)
$size_{it}$	0.0008***	0.0009***	0.0009***	0.0009***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
q_{it}	0.0012***	0.0007**	0.0004	0.0007**
	(0.0003)	(0.0003)	(0.003)	(0.0003)
year dummy	Inclusive	Inclusive	Inclusive	Inclusive
Observations	4722	4722	4722	4722
R^2	0.102	0.096	0.096	0.101
Hausman statistics (x_k^2)	68.95***	172.63***	65.37***	75.62***
	(<1%)	(<1%)	(<1%)	(<1%)

5.5. Robustness test: endogeneity bias test by using instrumental variables

For robustness, this subsection tests for an endogeneity bias of explanatory variables on FE panel regression results in Table 4 for the full sample. To the end, we use a 2SLS (two stage least squares) method using instrumental variables (IV) of the 1st lag of the explanatory variables ($bank_{it}$, $bond_{it}$ and seo_{it}). Results for this test are given in Table 8. Fundamentally, the results in Table 8, which are also very similar with ones in Table 6 above, are in accordance with those obtained by not accounting for endogeneity bias on the explanatory variables. Based on the results, we can strongly suggest that our findings without instrumental variables still remain valid.

6. Conclusions

This paper targeting Korean listed firms examines various impacts of external financing by subdividing it into bank loans and bond and stock issues on TIA proxied by R&D expenditures for the full sample period of 1st January 2000 to 31st December 2008.

Principally, we find evidence that the indirect external financing of bank loans commonly makes a negative impact on TIA of Korean listed firms but that of very plenty bank loans does a contrasting impact on it. Meanwhile external financing of security (i.e., bond, stock) issues does a positive one on it. The results support the hypothesis of manager discretion that banks' conservative lending criteria demanding considerable collaterals from firms discourage managers from an investment in TIA with high risk-high return while external financing via the security issues grants managers discretion for their TIA. For high tech firms, external financing of security issues makes no impact on their TIA unexpectedly. It could be said that as TIA is a principal source for future outcomes for firms categorized in high tech industries, they still have great incentives to keep TIA irrespective of financing factors. In addition, our study finds a significant relation between external financing of a bank loan and TIA for Korean *chaebol* affiliated firms. In association with the effects of external financing via bond and stock issues, the former makes a negative effect on TIA of the *chaebol* affiliated firms while the latter does a positive one on it. This would be explained by a nature of huge collaterals of *chaebol* affiliated firms in Korea. However, the results for non-*chaebol* affiliated firms, where relatively hold poor collaterals, are qualitatively similar with ones for the full sample.

In a nutshell, the direct external financing of security issues is positively associated with active TIA of Korean listed firms due to further manager discretion. The indirect external financing of via bank loans is negatively associated with it due to the conservative criterion of bank loans for risky TIA. Even if so, firms' availability of the extreme bank financing may allow managers to be willing to positively account for bank loans for financing TIA of their firms, despite one possible restriction of their managerial discretion.

There is a wide range of a policy and strategy significance from the results. First, from the former results, managers should be sensitive to maximizing in value of firms through a substantial increase of firms' profits and to improving the transparence of providing security investors with firms' financial information to effectively attract capital of securities (i.e., stocks and bonds) for TIA. The positive impact of the indirect external financing via the accessibility of the large (doubled) bank loans on TIA of firms also provide managers with a meaningful implication to ameliorate the negative one of the external financing of the original bank loans on it. That is, managers need to contemplate strategic policies to enhance the credibility of their firms to their main creditors (i.e., banks) for securing large enough bank loans to effectively succeed in firms' TIA. Eventually, our study may provide managers who seek for maximization in value of firms in emerging economies

such as Korea via a successful technological innovation with meaningful implications for an appropriate financing approach for it. In an academic perspective, this study using firms in Korea, one of leading emerging economies, extends to the existing literature that mostly concentrate on the case of firms in advanced countries.

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