

# Banking Crises, Financial Constraints, and Innovation\*

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## Abstract

This paper examines the relationship between financial constraints and innovation with panel data for exchange-listed manufacturing firms across 32 countries over the time period of 1994 through 2012. We explore the effects of corporate financial constraint on innovation under banking crises. Firms with low debt, high long-term debt, and high equity turn out to increase research and development (R&D) expenditure during banking crises. Also, cash holdings appear to determine R&D expenditure in the sample without banking crisis experiences.

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## I. Introduction

This paper investigates the relationship between financial constraints and research and development (R&D) expenditure considering

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banking crisis experience, using cross-country firm-level data during the period from 1994 until 2012.

This study is related to a number of literatures. First of all, this paper is relevant to firm heterogeneity and R&D investment. Lee and Sung (2005) analyze the determinants of R&D considering technology competence. Brown et al. (2009) provide empirical evidence of the relationship between external financing and R&D investment, considering firm specific characteristics. Their analysis concentrates in the difference between young and mature firms.

Our research contributes to the literature on internal and external financing and R&D investment. Himmelberg and Petersen (1994) support that internal financing is the primary determinant of R&D investment due to capital market imperfection. The impact of variation of cash holdings on R&D is also estimated by Brown and Petersen (2011). Their empirical evidence explains how corporate liquidity affects corporate R&D investment. Although R&D investment is a key factor to improve productivity (Aw and Song, 2013)), some high-tech corporations' innovation projects cannot be perfectly financed by capital market growth due to capital market imperfection. Hyytinen and Toivanen (2005) argue that financial constraints could contract corporate innovation activity and government funding remarkably support firms' innovation activity, especially in the industries that are highly dependent on external financing. Lee et al. (2013) also address that public policy should be designed in consideration of providing economic incentives of innovation especially for the small and/or high-technology firms. Colombo et al. (2014) find that informal risk capital can reduce financial constraint in high-tech firms.

In this paper, we also aim to provide empirical evidence that financial crisis experiences and constraints could affect firm R&D activities. Filippetti and Archibugi (2011) investigate the relationship

between business cycle and innovation. They argue that the impact of the economic recession on innovation investment can be different depending on some structural characteristics. They find that structural factors determine whether corporate innovation activity could be cyclical or counter-cyclical. Additionally, development of the financial system is one of the structural factors that can affect innovation. The impact of financial development on technological innovation is examined by Hsu et al. (2014). Their results support that credit market development turns out to discourage innovation, while the capital market encourages innovation.

This paper explores the conjecture that the relationship between financial constraints and R&D investment can vary depending on banking crisis experiences. While Makkonen (2013) examines innovation in times of crisis concentrating on the pro-cyclical and counter cyclical characteristics, we discuss the determinants of R&D expenditure considering firms' financial heterogeneity. Cash holdings, debt, long-term debt, and equity can play different roles with respect to banking crisis experiences. Although the effect of cash holdings has been widely examined in the previous literature, few studies have taken into account of debt or long-term debt. Our empirical results could provide policy implications to stimulate corporate innovation activities, considering various sources of funding.

## **II. Empirical Model and Data**

Our sample includes exchange-listed manufacturing firms across 32 countries over the time period of 1994 through 2012. We conduct empirical analyses using panel GMM method suggested by Arellano and Bover (1995). Brown et al. (2009) and Brown and Petersen (2011) conduct empirical exercises using dynamic R&D model.

We develop the following empirical model:

$$\begin{aligned}
RD_{it} = & \beta_0 RD_{it-1} + \beta_1 RD_{it-1}^2 + \beta_2 Cash_{it-1} \\
& + \beta_3 Debt_{it-1} + \beta_4 Equity_{it-1} + \beta_5 GovRD_{jt} \\
& + \beta_6 GDPgrowth_{jt} + F_i + D_t + \epsilon_{it}
\end{aligned} \tag{1}$$

The dependent variable is the R&D expenditure for firm  $i$  at time  $t$ . All the firm-specific variables, R&D, cash holdings, debt, and equity, are scaled by firms' assets. The coefficient of lagged R&D is expected to have a positive sign, while the quadratic term negative. We also use long-term debt to specifically analyze the impact of debt on innovation. Total debt and long-term debt is adopted as debt variable in empirical analyses. GovRD and GDP growth for country  $j$  at time  $t$  are also among the covariates. GovRD is formulated by government expenditures for research and development to GDP ratio, and GDP growth rate is calculated by annual percentage growth rate of GDP. Firm specific and year effects are controlled for. Firm specific financial variables are available on Worldscope and country specific variables are obtained from the World Bank database.

Referring to Valencia's (2012) database, we classify our sample with countries that had experienced banking crises versus those not. Table 1 reports the summary statistics of the aforementioned variables. Firms in countries with banking crises tend to have higher R&D-to-asset, debt-to-asset, long-term debt-to-asset ratios, and lower cash-to asset, equity-to-asset ratios, compare to those companies in countries without banking crises. Outliers of the variables are trimmed at the 1% level.

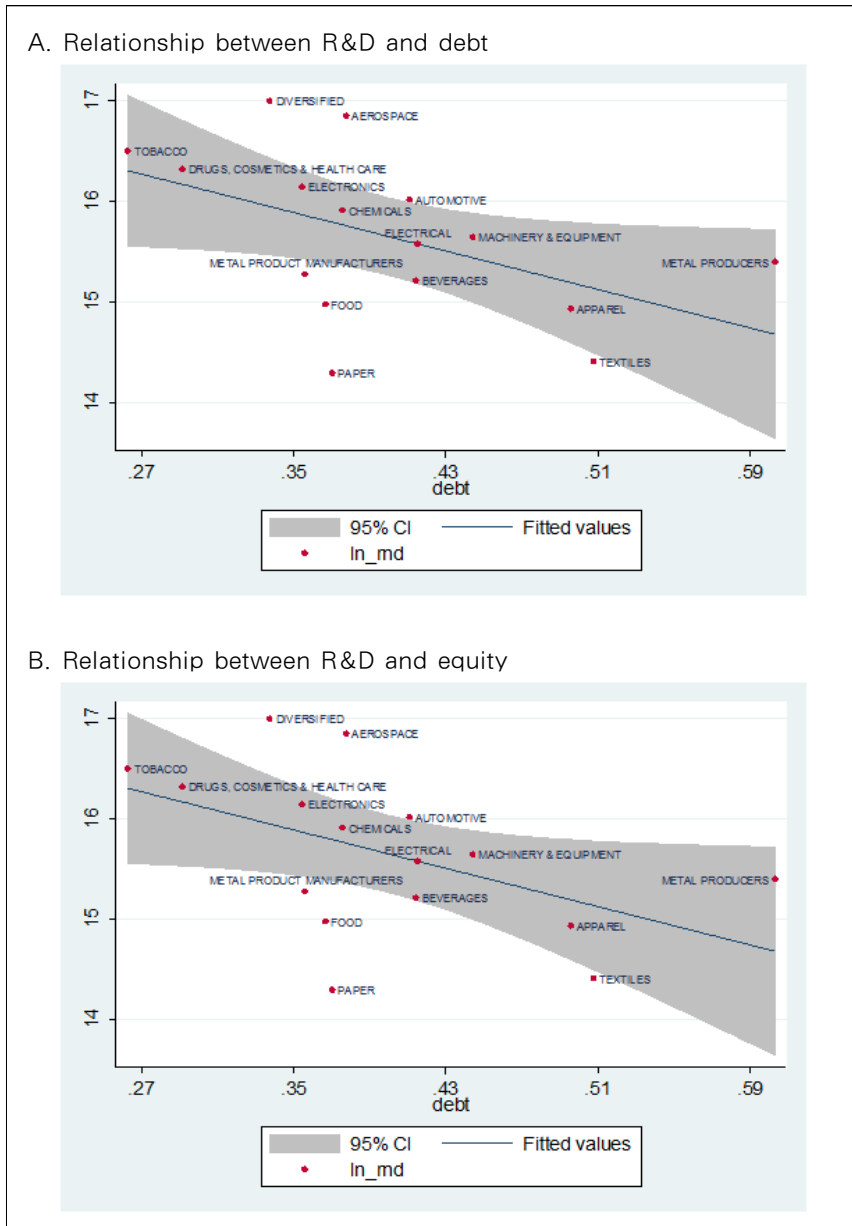
Figures 1 and 2 show the relationship between debt, equity and R&D during the crisis and non-crisis periods. We calculate the industry average of the log of R&D expenditure, debt-to-asset, and equity-to-asset ratio to illustrate these figures. Worldscope's industry specification is adopted.

[Table 1] Table 1 Summary statistics of variables (1994-2012)

Variables	(1) Total sample			(2) Including firms in the countries w/ banking crisis			(3) Including firms in the countries w/o banking crisis			Difference: (2)-(3)	t-test
	No. of obs.	Mean	Std. dev.	No. of obs.	Mean	Std. dev.	No. of obs.	Mean	Std. dev.		
R&D	61947	0.084	0.371	55293	0.086	0.388	6654	0.064	0.165	0.022*** (0.005)	
Debt	61947	0.342	0.355	55293	0.348	0.363	6654	0.298	0.278	0.050*** (0.005)	
Long-term debt	61783	0.112	0.199	55177	0.114	0.199	6606	0.094	0.198	0.020*** (0.003)	
Cash	61947	0.141	0.177	55293	0.139	0.177	6654	0.158	0.180	-0.020*** (0.002)	
Equity	61947	0.461	0.445	55293	0.450	0.451	6654	0.551	0.377	-0.101*** (0.006)	

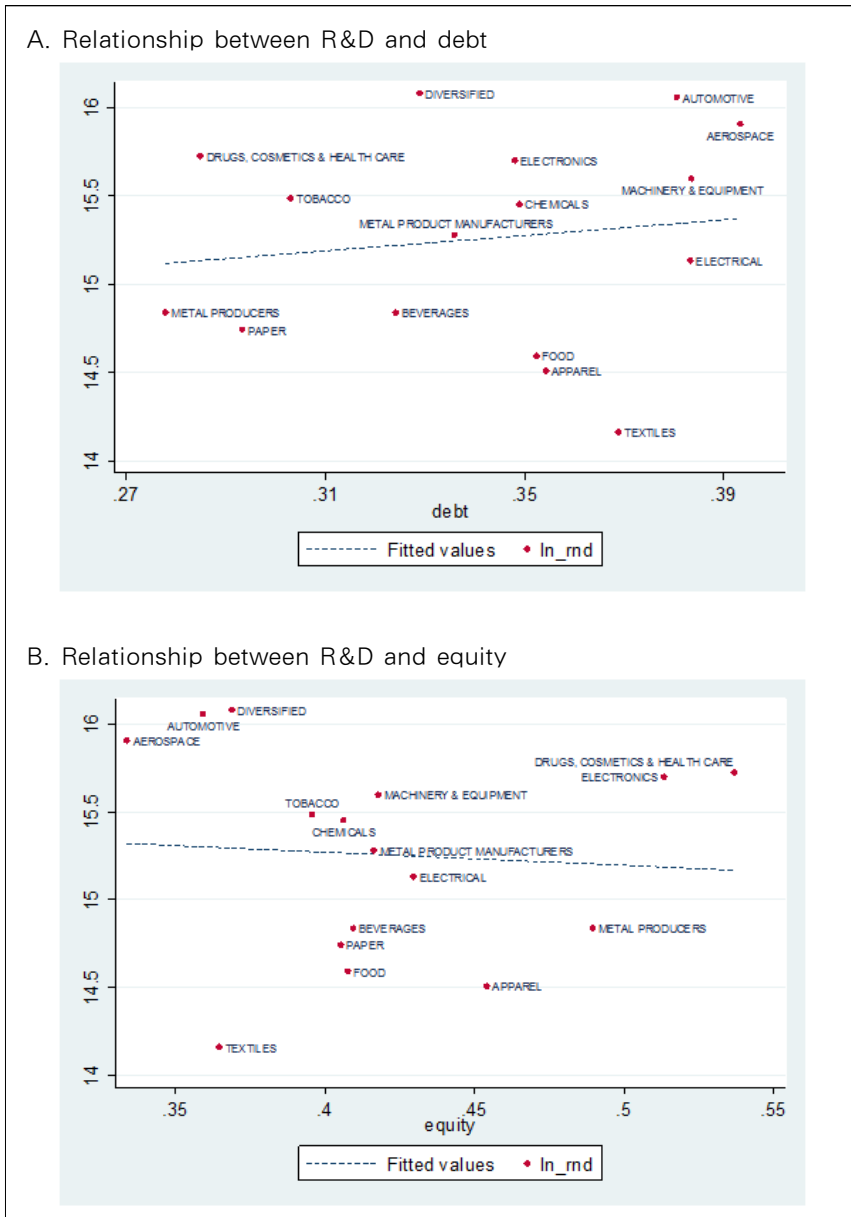
Notes: All the variables are scaled by firm assets; Outliers of the variables are excluded at the 1% level; Standard errors are in parentheses; \*\*\* p<0.01.

**[Figure 1]** R&D financing in the crisis periods



Note: y-axis represents industry average of log of research and development expenditure, and industry average of x-axis is debt-to-asset ratio or equity-to-asset ratio.

**[Figure 2]** R&D financing in the non-crisis periods (Industry average)



Note: y-axis represents industry average of log of research and development expenditure, and industry average of x-axis is debt-to-asset ratio or equity-to-asset ratio.

We can find a negative relationship between debt and R&D in crisis periods in Figure 1A while Figure 1B displays that industry

equity and R&D is positively correlated. In Figure 2, we plot the industry average of the debt, equity, and R&D in non-crisis periods. The graph confirms that there is no significant correlation between R&D and debt-to-asset, and equity-to-asset ratios.

Debt and equity financing turn out to have important roles in the periods of the banking crisis. We can predict a negative relationship between debt and R&D, and a positive relation between equity and R&D.

### **III. Empirical Results**

Our empirical results using total debt variable is reported in Table 2. Over-identifying restrictions cannot be rejected in all empirical models. Debt financing has a negative impact on R&D expenditure while equity financing is positively related to R&D in the whole sample. These results also hold in the sample with banking crisis experiences. Cash holdings do not play an important role neither in the whole sample nor sample under banking crises, but turn significant in the sample without banking crises. In other words, external and equity financing is important in the sample with banking crises, while cash holdings become more important in explaining R&D expenditure other than the periods under banking crises.

Table 3 shows the analysis results using long-term debt instead of total debt. Column (1) explains that firms with higher long-term debt and equity financing tend to have higher R&D expenditure in the whole sample. This relationship is also significant in the sample with banking crises, while the relationship becomes insignificant in the sample without banking crises. Cash holdings play an important role in the sample without banking crisis. The long-term debt could be a



key factor to boosting R&D expenditure in countries with banking crisis experiences.

Firms in countries with banking crisis experiences have a higher probability of facing financial constraints, thus raising long-term debt and managing leverage soundly would be helpful for R&D investment. Since the firms in countries without banking crises tend to depend on cash holdings, expanding debt and equity financing is necessary to catalyze innovation activities.

**[Table 2] Panel GMM results for the period from 1994 to 2012**

Dependent Variable	R&D		
	(1)	(2)	(3)
	Total sample	Including firms in the countries w/ banking crisis	Including firms in the countries w/o banking crisis
R&D(t-1)	0.2869*** (0.069)	0.2938*** (0.073)	0.8797*** (0.213)
R&D(t-1) <sup>2</sup>	-0.01124*** (0.004)	-0.01142*** (0.004)	-0.4127*** (0.115)
Cash(t-1)	0.02556 (0.025)	0.02256 (0.026)	0.08131* (0.043)
Debt(t-1)	-0.07184*** (0.025)	-0.07033*** (0.027)	-0.08179 (0.079)
Equity(t-1)	0.06389*** (0.015)	0.06672*** (0.015)	-0.05224 (0.074)
Gov R&D	0.00238 (0.020)	0.00754 (0.026)	0.05466 (0.056)
GDP growth	0.00083 (0.001)	0.00096 (0.001)	-5.10E-05 (0.002)
Constants	0.00772 (0.047)	-0.00588 (0.061)	-0.06322 (0.115)
Year Dummies	Yes	Yes	Yes
N	55986	50478	5508
Chi2	247.7***	260.1***	108.2***

Notes: All the variables are scaled by firm assets; Heteroskedasticity-robust standard errors are in parentheses; Over-identifying restrictions cannot be rejected in all empirical models: \* p<0.1; \*\*\* p<0.01.

**【Table 3】** Panel GMM results for the period using long-term debt from 1994 to 2012

Dependent Variable	R&D		
	(1)	(2)	(3)
	Total sample	Including firms in the countries w/ banking crisis	Including firms in the countries w/o banking crisis
R&D(t-1)	0.2837*** (0.068)	0.2907*** (0.072)	0.8803*** (0.209)
R&D(t-1) <sup>2</sup>	-0.01117*** (0.004)	-0.01135*** (0.004)	-0.4143*** (0.112)
Cash(t-1)	0.02253 (0.024)	0.01917 (0.026)	0.08207* (0.044)
Debt(t-1)	0.04822** (0.021)	0.04831** (0.024)	0.1046 (0.088)
Equity(t-1)	0.1218*** (0.026)	0.1235*** (0.027)	0.03142 (0.031)
Government R&D	0.00509 (0.020)	0.01113 (0.026)	0.05305 (0.056)
GDP growth	0.00091 (0.001)	0.00106 (0.001)	-6.90E-05 (0.002)
Constants	0.00877 (0.055)	-0.06988 (0.070)	-0.1433* (0.084)
Year Dummies	Yes	Yes	Yes
N	55905	50420	5485
Chi2	262.6***	279.5***	108.9***

Notes: All the variables are scaled by firm assets; Heteroskedasticity-robust standard errors are in parentheses; Over-identifying restrictions cannot be rejected in all empirical models; \*  $p < 0.1$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ .

## IV. Conclusion

This paper explores the impacts of cash holdings, debt, and equity on R&D spending with a focus on financial crises. Our empirical results support that debt and equity financing appear to be important determinants of R&D expenditure in the sample with banking crises,

while cash holdings play an important role in the sample without banking crisis experiences. Long-term debt turns out to be positively related to R&D investment. Financial constraints can contract corporate innovation activities in during banking crises.

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## 금융위기, 재무적 제약조건과 혁신

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### 논문초록

본 연구는 1994년부터 2012년까지 32개국의 거래소에 상장된 제조 기업을 대상으로 기업의 재무적 제약과 혁신간의 관계를 분석하였다. 특히 금융위기 때 기업의 재무적 제약이 혁신에 미치는 영향을 분석하였다. 그 결과 부채가 적고, 장기부채가 많으며 높은 주가 수익률을 가진 제조 기업은 금융위기 시에 연구개발 지출이 증가함을 관찰할 수 있었다. 또한 금융위기를 배제한 데이터의 분석에서는 보유 현금의 양이 연구개발 지출에 영향을 미치는 것으로 분석되었다.

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핵심 주제어 : 연구개발비, 외부 금융, 금융 위기

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