Monetary Policy Shock and R&D Investment – Evidence from Korea[+]

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A B S T R A C T

I provide evidence on the effect of monetary policy shocks on research and development (R&D) in setting with and without firm-specific variables. I identify monetary shocks by orthogonalizing policy rate change with respect to economic forecast information. Using the shock, I examine the responses of the R&D expenses to increase in the short-term interest rate changes in two monetary transmission channels: Asset price channel and balance sheet channel. The empirical results prove that R&D investment gradually decreases in response to monetary policy shock. However, this trend becomes less apparent for *chaebols*, unique form of conglomerate in Korea, which could be due to their access to internal financing, while the R&D investment of non-*chaebols* to monetary policy shock decrease at statistically significant level. This research also implies that the degree to which firms reduce R&D investment may depend on the affiliation to *chaebols* when the level of leverage is considered.

JEL Classification: B22, E44, O32

Keywords: Chaebols, Internal Financing, Monetary Policy Shock, R&D Investment, Korea

Ⅰ. Introduction

Recent years have witnessed the vast amounts of research on the monetary policy transmission to firm-specific factors (Ben and Gertler, 1995; Casiraghi et al., 2021; Chatelain et al., 2003; Cloyne et al., 2018; Durante et al., 2020; Xu, 2020). Importantly, comprehending monetary policy transmission is crucial to making monetary policy and business decisions. To examine monetary policy transmission empirically, it is essential to identify monetary policy measures which are exogeneous to the macro-economic and financial variables of interest.

Recently, a number of empirical strategies have been proposed including the vector autoregressive (VAR) framework (Bernanke et al., 2005; Christiano et al., 1996), non-recursive ordering restriction (Bernanke and Mihov, 1998) and orthogonalized monetary policy rate changes with respect to economic forecasts (Cloyne and Hürtgen, 2016).
In my research, I identify monetary policy shocks and examine the effectiveness of the policy over the period of 2009-2021 on quarterly basis. In particular, I analyze the responses of the level of firms' investment of research and development (R&D hereafter) to the transmission of 'orthogonalized' policy rate in Korea. While previous research has mainly examined the effect of monetary policy on capital investment at international and regional level (Bloom et al., 2007; Cloyne et al., 2018; Gulen and Ion, 2015; Kang and Lee, 2022), I

[+] This paper is based on the third chapter of the author's Ph.D. thesis, 'Three Essays on Korean Capital Market' and does not necessarily reflect the official position of Kakao.

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focus on how R&D investment of Korean firms may react differently to monetary policy through the lens of (i) the asset price channel and (ii) the balance sheet channel. In particular, I separate firm samples into two different categories – *chaebols*, unique form of conglomerates and non-*chaebols* – in order to capture if unique characteristic that originate from Korean business atmosphere determines their tendency to increase or decrease R&D investment. As well, I add firm-specific conditions such as Tobin's Q, asset size and leverage, to the response of monetary policy shock in more detail.

My analysis is conducted in two steps, which are identification step and estimation step. For the first step, I regress the observed rate of monetary policy rate on the information set available to the monetary policy board. Following the methodology of Lee and Park (2022), my information set is composed of real-time data or forecasts for real growth of gross domestic product and CPI (Consumer Price Index) from 2009 to 2021 over horizons of up to a quarter before and ahead, and on the forecast revisions from those information sets available at the preceding meetings. Then, the residuals obtained from the regression are considered 'monetary policy shock'. In order to construct the historical information set used in monetary policy decisions, I manually check the historical press release, *the Economic Outlook*, which provides economic forecasts including real gross domestic product (GDP) and inflation (CPI) on quarterly basis, prepared by Bank of Korea (BOK) staff. Subsequently, in the estimation step, I measure the dynamic responses of the variables of concern, the expense of R&D along with a set of firm-specific variables including growth of investment ratio, Tobin's Q, leverage ratio, cash flow, total asset, sales, firm's age, collateral asset, and macroeconomic variables including real Gross Domestic Product (GDP), Consumer Price Index (CPI), call rate, federal fund rate and so on.

In this research, I consider two main channels through which monetary policy shock influences the R&D investment of Korean firms: (1) The asset price channel; and the balance sheet channel. First, the asset price channel is the channel through which monetary policy shock affects the price of firms' assets. The two main ways through which monetary policy shock transmits are: Changes in the value of Tobin's Q and asset size of firms. Second, the balance sheet channel implies that the tightening of monetary policy creates tighter financial conditions for Korean firms. The firms with low quality of balance sheet would be negatively influenced, which affects "their investment and spending decisions" on R&D investment (Bernanke and Gertler, 1995).

The major findings of my research are as following. First, Korean firms, in general, tend to reduce the investment for R&D in response to monetary policy shock. This trend has strengthened for non-*chaebols* which do not enjoy internal financing, unlike their counterpart, *chaebols*. Second, the analysis for asset price channel suggests that the R&D investment of firms with high Tobin-Q and asset volume are more responsive to monetary shock than the ones with low Tobin-Q, which is consistent with notions that firm-level market uncertainty on R&D investment diminish as the size of firm increases (Cho and Lee, 2021; Czarnitzki and Toole, 2013; Ghosal and Loungani, 2000). Third, the analysis for balance sheet channel suggests that the R&D investment for non-*chaebols* with low leverage

steadily increase, in contrast with *chaebols* in which firms with high leverage experience the decrease in R&D investment.

My study makes several contributions. First, I add to the growing literature on monetary policy and R&D investment in emerging market by addressing key firm-specific and macroeconomic variables which are unique to Korean firms. Second, I extend prior research on asset price channel and balance sheet channel by identifying Tobin's Q, firm size and leverage as key factors in determining the relationship of monetary policy shock and R&D investment. Third, separately analyzing *chaebols* and non-*chaebols*, I identify unique characteristics of *chaebols* that distinguishes itself from non-*chaebols*. Specifically, it seems rational that the access to internal financing through the network channel within affiliates, have them less dependent on external funding for R&D investment, whereas non-*chaebols*, which do not enjoy such internal financing like *chaebols*, would decrease its R&D investment due to the one unit increase of monetary shock as measured by policy rate, which would be discussed in detail.

The rest of my paper is composed as follows. Section 2 presents previous researches and theoretical motivation for hypothesizing a link between monetary policy shock and R&D investment. Section 3 describe data and methodology. Section 4 presents the results of analysis with robustness check. Section 5 provides economic implications and Section 6 concludes.

Ⅱ. Literature Review

Ⅱ-1. Monetary policy shock and R&D investment

There is widely held belief that R&D yields positive externalities, which motivate external support and tax incentives from government agencies. According to previous researches, monetary policy shock is one of critical factors in determining R&D investment at firm level (Cho and Lee, 2021; Czarnitzki and Toole, 2013; Ghosal and Loungani, 2000). How does the effect of monetary shock on R&D investment differ from that on capital investment? Market uncertainty as measured by monetary policy shock, is essential in decision-making process for physical capital or fixed assets (Bloom et al., 2007).

Traditionally, financial option theory is typically employed to explain the relationship between monetary policy and uncertainty and capital investment (Dixit and Pindyck, 1998; Abel et al, 1996). The key idea is that a firm making a reversible investment decision gain a put option and is willing to invest today even if future uncertainty has a sufficiently large downside. However, this firm is willing to invest if it has option to 'reverse the decision (Trigeorgis, 2002)'. Thus, if the investment decision is regarded as 'irreversible choice' if the firm has a call option and would be unwilling to invest if future uncertainty leads to a large downside (Dixit and Pindyck, 1998). Specifically, the investment for R&D could become sunk costs for salaries of researchers, task-specific equipment and materials (Czarnitzki and Toole, 2011). In this context, it is reasonable to assume that increase in market uncertainty would reduce R&D investment.

On the other hand, some research point out that firm size influences the effect of R&D investment. For instance, Czarnitzki and Toole (2013) note that there exists uncertainty-R&D investment relationship and its relationship with firm size. To be specific, they find that market uncertainty at firm level diminishes as firm size increases. Wang et al (2017) note that market uncertainty poses a clear impact on the investment for R&D for firms without political connection but has no impact on firms with political connections.

Further, previous researches note that credit tightening due to monetary uncertainty slows economic activity including R&D investment (Aysun and Kabukcuoglu, 2019; Czarnitzki and Toole, 2011; Ghosal and Loungani, 2000) For example, Aysun and Kabukcuoglu(2019) argue that credit tightening pushes firms into less volatile activities which are more conducive to economic growth. Specifically, they note that if firms receive incentives in the form of grants and subsidies, their share of R&D would increase during a credit tightening. Conversely, however, if tax credits are the major incentive, they would decrease their share of R&D spending during a credit tightening.

Interestingly, the relationship of monetary shock and R&D investment is at least, party determined by industry characteristics. For example, after analyzing Chinese pharmaceutical manufacturing enterprises from 2012 to 2018, Yang et al. (2021) find a negative correlation between monetary policy uncertainty and R&D investment smoothing behavior. They further argue that the shorter the period, the higher the financing constraints of pharmaceutical enterprises are.

Ⅱ-2. Monetary policy shock, R&D investment and Korean firms

R&D is among the most important drivers of corporate investment in Korean business environment. According to CEO Score, a Seoul-based business data tracker, 224 out of top 500 firms in Korea have invested combined 60.4 trillion won in developing, designing, and enhancing products and services, which amounts to 47 billion dollars. The institution further notes that for the first time, Korean firms' spending for R&D exceeded 60 trillion won.1

Despite the increasing volume of the R&D investment, a limited number of researches focus on the relationship of monetary shock and R&D investment in Korea. In particular, previous researches point out the importance of internal financing which help cost efficiencies of *chaebols*. These *chaebols* have played a major role in Korea's dramatic economic growth under the government's support. However, over the last decades, critics' demand for their reformation has grown because of their association with political scandals, which causes owner risk. During the East Asian Financial crisis of 1997, *chaebol*-affiliates generated more stable profits compared to non-*chaebol* affiliates due to a well-functioning internal financing market within affiliates. In perspective of asset allocation, investors would not be able to enjoy the benefits of stable and large cash flow generation if they invest in non-

[1] Jeehyun Cho, Corporate Korea's R&D spending tops $47 bn in 2021, led by Samsung Electronics, April, 27th, 2022. URL: https://pulsenews.co.kr/view.php?year=2022&no=375042

chaebols. The access to internal financing, in turn, delivers stable profit generation which leads to stable business management in economic crisis. For example, Kwon et al. (2018) find that cost stickiness is on average, greater in *chaebol*-affiliates than non-chaebols, which is due to their internal resources that allow them to maintain their level of R&D investment. As well, they note that their R&D cost stickiness is more pronounced in post-global financial crisis in 2008. In this respect, with or without sufficient loans and grants from government, tightening credit conditions due to the increase of policy rate would cause non-*chaebols* less reliant on external funding and thus reduce R&D investment, leading to decrease in the share of R&D activity. In other words, cost advantages that come from government subsidy could become relatively less important at higher interest rates, so that non-*chaebols* which do not take advantages of internal financing like *chaebols*, would likely to decrease their R&D investment.

The Figure 1 below presents the trend of interest rate and R&D investment for Samsung Electronics, a leading manufacturing firm of electronic devices, on quarterly basis from 2009 to 2021. Here, the y-axis to the left and right refer to call rate in Korea and R&D investment in this *chaebol*-affiliated firm scaled by total asset. This trend vividly presents the tendency of the firm's R&D investment to gradually decrease in line with the gradual decrease of interest rate. On the other hand, subsequently, Figure 2 illustrates the trend of another manufacturing non-*chaebol* firm, Hwacheon Machine Tool. In contrast with Samsung Electronics, the R&D investment of this firm drastically reduces in response to the increase of call rate in early 2010 and barely increase back to the level since then.

Figure 1. Trend for Monetary Policy Rate and R&D Investment for Samsung Electronics during 2009-2021 on quarterly basis

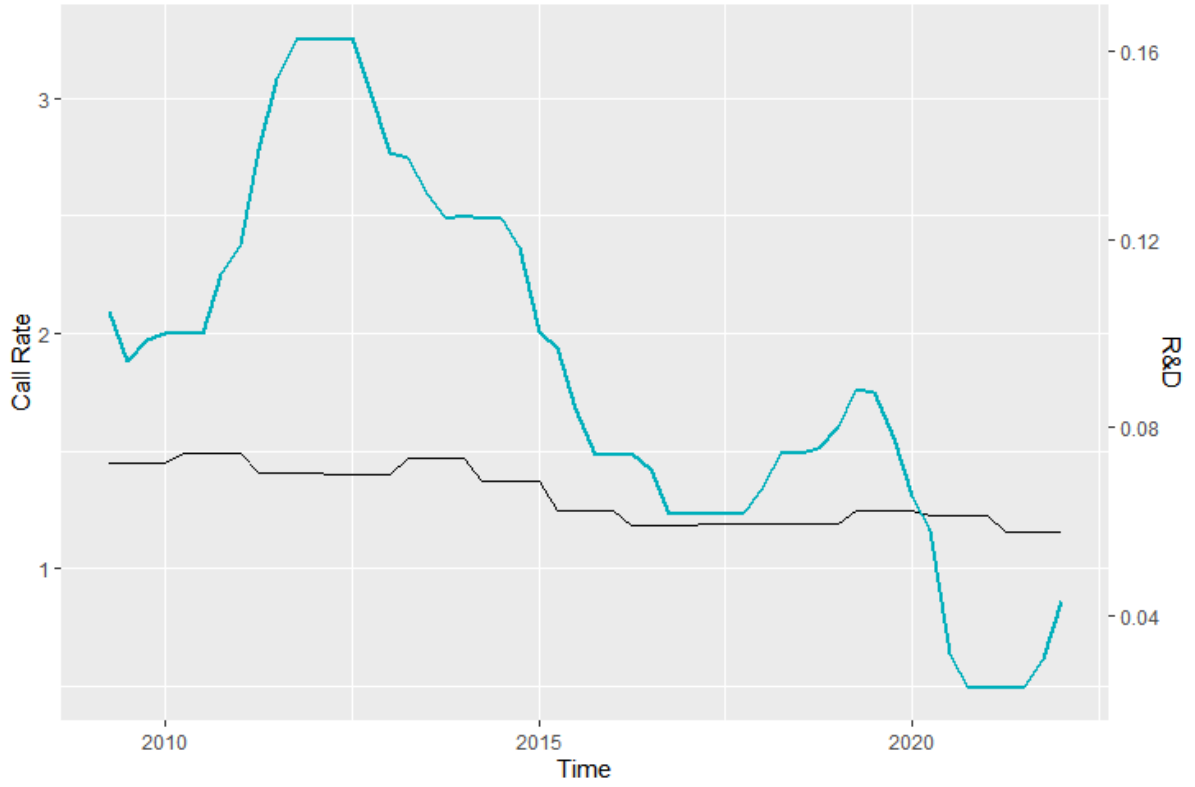
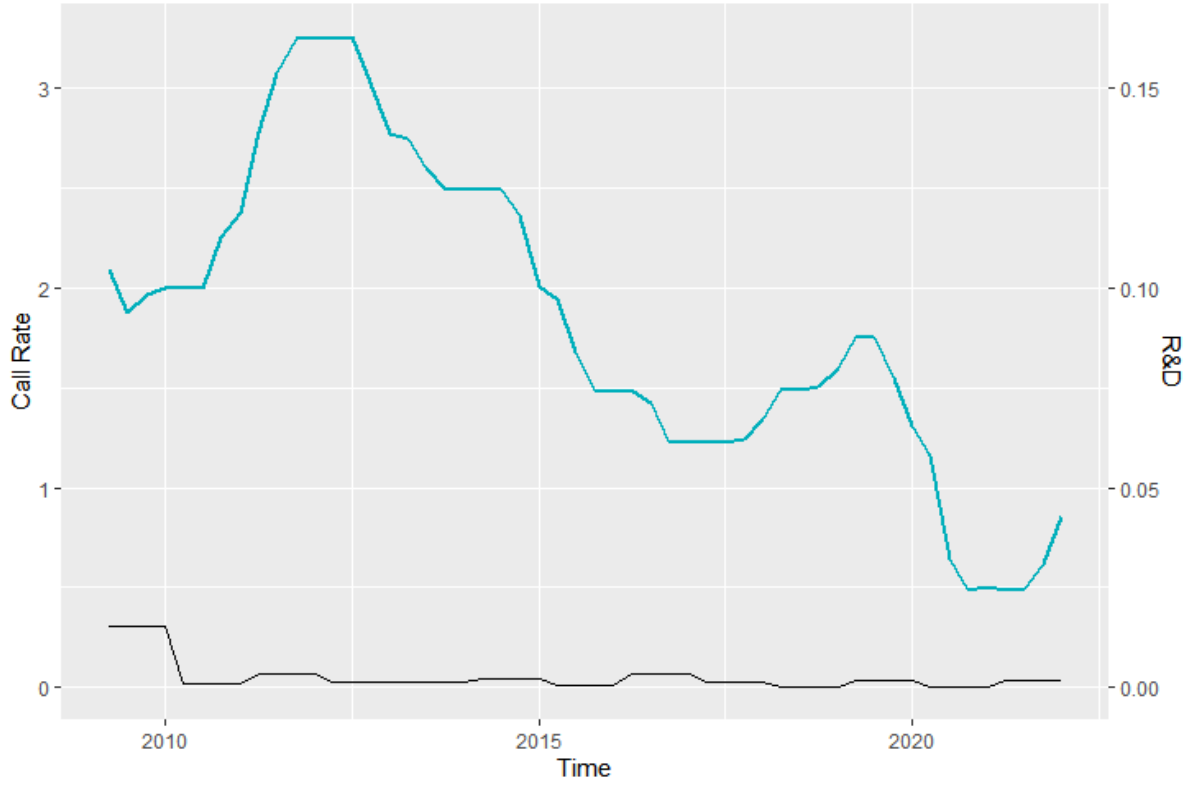


Figure 2. Trend for Monetary Policy Rate and R&D Investment for Hwacheon Machine Tool during 2009-2021 on quarterly basis



Ⅲ. Data summary and Empirical Model

Ⅲ-1. Financial and macroeconomic variable

In this section, I explain sample distribution and variable definition. First, I exclude firms affiliated to finance or insurance industries. Then, in order to observe deterministic characteristic of impulse response of R&D investment to monetary shock, I split firm samples into *chaebols* and non-*chaebols*. In my sample, all firms are 1,042, which is composed of 277 *chaebols* and 929 non-*chaebols*. As well, the number of observations for all firms, *chaebols* and non-*chaebols* are 54,185, 9,773 and 44,413 respectively.[2] The information for sample and observation number for all firms, *chaebols* and non-*chaebols* is presented in Table 1 below.

Table 1. The sample and observation number of all firms, chaebols and non-chaebols
(2009-2021 on quarterly basis)

	All firms	Chaebols	Non-chaebols
Sample	1,042	277	929
Observation	54,185	9,773	44,413

Subsequently, I download Korean macroeconomic data and primary firm data, including Korean firms listed on KOSPI, from Dataguide, which is database run by FNguide, Korean financial information company. The observation period runs from 2009 to 2021 on quarterly basis. I also download U.S. macroeconomic data from FRED (Federal Reserve Economic Data) webpage.[3]

The dependent variable is expense for R&D(RD) which is scaled by total assets. As well, I include basic firm factor variables to my model, which are sales growth rate (*SG*) and current asset ratio (*CAP*), following Ottonello and Winberry (2020). Also, the firm-specific control variables include growth of investment ratio (*GIR*), Tobin's Q(*TQ*), leverage ratio (*LEV*), cash flow (*CF*), total asset (*Size*), firm's age (*Age*), collateral asset (*Col*). which would be control variables. Korean macroeconomic variables include real gross domestic product (*KGDP*), consumer price index (*KCPI*) and call rate (*CR*), and U.S. macroeconomic variables include gross domestic product for previous quarter (*USGDP(t-1)*), federal fund rate (*FFR*), CPI(*USCPI*) and dollar/won exchange rate (*EXR*). The detailed definition for each variable is presented in following Table 2.

[2] The number of sample and observations for *chaebols* and non-*chaebols* do not sum up to the number of all firms, since for every year the firm status of *chaebols* could be assigned to non-*chaebols* and vice versa, by the decision of KFTC.

[3] The Bank of Korea started to publish quarterly data for GDP and CPI since 3rd quarter in 2012, so that the data before the period is semi-annual basis.

Table 2. Firm and macroeconomic variables

Specification	Var. name	Variable	Reference
Dep. variable	RD	Expense for R&D	
Firm-specific factor	GIR	Growth of Investment Ratio	Log of sum of tangible asset for current and former quarter
	TQ	Tobin's Q	Sum of Market Value and Total Debt/Total Asset
	LEV	Leverage ratio	Total Debt/Total Asset
	CF	Cash Flow	Sum of Operating Profit and Operating Cost/ Total Asset
	Size	Total Asset	
	Sales	Sales	
	Age	Firm's age	Quarterly basis
	Col	Collateral asset	Sum of Tangible Asset, Inventory and Account Receivable
Other firm factor	SG	Sales Growth Rate	Year on year basis
	CAP	Current Asset Ratio	Current Asset/Total Asset
Korean macro-factor	KGDP	GDP in Korea	
	KCPI	CPI in Korea	
	CR	Call rate in Korea	Unsecured loan basis
U.S. macro -factor	USGDP (T-1)	GDP (previous quarter) in the U.S.	Previous to Current Quarter
	FFR	Federal Fund rate	
	USCPI	CPI in U.S.	
	EXR	Dollar/won exchange rate	Trading basis

Ⅲ-2. Estimating Monetary policy shock

So far, a number of identification schemes have been proposed in a variety of literature to estimate impulse response to monetary shock (Jordà, 2005; Kang and Lee, 2022; Lee and Park, 2022). Equation (1) below presents the regression model in identifying monetary policy shocks.

Following the methodology introduced by Lee and Park (2022), I regress observed policy rate changes on the information set which are available in press release of the Bank of Korea. The information set includes hand-collected real-time forecast data for output growth and inflation from 2009 to 2021 over horizons of up to a quarter ahead. The regression specification is as the following.

$$\Delta i_m^{target} = \alpha + \beta i_{m-1}^{target} + \sum_{j=-1}^{1} \gamma_j \Delta \tilde{y}_{m,h} + \sum_{j=-1}^{1} \lambda_j \left(\Delta \tilde{y}_{m,h} - \Delta \tilde{y}_{m-1,h} \right) + \sum_{j=-1}^{1} \Psi_j \tilde{\pi}_{m,h} + \sum_{j=-1}^{1} \theta_j \left(\tilde{\pi}_{m,h} - \tilde{\pi}_{m-1,h} \right) + \varepsilon_m$$

In the equation, Δi_m^{target} is the change of actual policy rate determined at the monetary policy decision-making meeting. The subscript j means the horizon of the forecast: -1 is the previous quarter; zero is current quarter; and 1 is one quarter ahead respectively. As well, i_{m-1}^{target} is the policy rate that prevailed before current meeting. Further, $\Delta \tilde{y}_{m,h}$ and $\tilde{\pi}_{m,h}$ refer to the forecast data for the real GDP growth rate and CPI inflation rate respectively. Lastly, ε_m mean the identified monetary policy shock, which would be used for my local projection model.

Ⅲ-3. Estimating Impulse response to Monetary policy shock

In estimating an impulse response, I use local projection model, which is introduced by Jordà (2005). In comparing to a vector autoregressions (VAR), which has been traditionally used in empirical macroeconomic researches, the key advantages of local projection model is abundant. While local projections are estimated by simple regression techniques, they are more robust to misspecification. As well, not only joint or point-wise analytic inference is simple, but also, they can easily accommodate experimentation with non-linear and flexible specifications which can be impractical in multivariate context (Jordà, 2005). More importantly, local projections methods are based on sequential regressions of the endogenous variables shifted a number of steps ahead so that has several points of commonality with direct multi-step forecasting.

The local projection models are as the following. The first equation excludes firm-specific control variables. The following second equation includes firm-specific control variables in order to better observe the impulse response of R&D to monetary policy shock when other firm-specific variables are controlled. I split the sample into *chaebols* and non-*chaebols* in order to capture the difference in their impulse response to monetary shock.

$$R_{j,h} = \alpha_{j,h} + \beta_h^{m,1} \varepsilon_t^m + \Gamma_h^m Z_{j,t} + \varepsilon_m$$

$$R_{j,h} = \alpha_{j,h} + \beta_h^{m,2} \varepsilon_t^m + \sum_{g=-1}^{G} Y_h^g X_{j,t} + \Gamma_h^m Z_{j,t} + \varepsilon_m$$

IV. Empirical Analysis

IV-1. Asset price channel

I present the graphical result for impulse response of R&D investment to monetary shock for each category of sample – all firms, *chaebols* and non-*chaebols*. I conduct analysis based on

Tobin's Q and firm size to verify the asset price channel. respectively. I define 'high TQ' as the firms with the values of Tobin's Q (firm size) which are larger than median value and vice versa. For each sample, I deliver the model without and with firm-specific control variables.

First, the following Figure 3 and 4 present impulse response to monetary shock without and with firm-specific variables for all firms. The trend in Figure 3 illustrates that impulse response of firms' R&D investment to monetary shock gradually decreases and increase at 9th quarter at statistically significant level. In particular, a similar pattern is observed for firm samples with high Tobin's Q and firm size; on the other hand, this pattern is not observed and statistically significant for firm samples with low Tobin's Q and firm size. When firm-specific control variables are controlled in Figure 4, the gradual decrease of R&D investment in response to monetary policy shock is observed from 6th to 9th quarter at statistically significant level. However, neither this pattern nor statistically significance is found for firm with both high and low Tobin's Q and firm size.

Figure 3. Impulse response to monetary shock without firm variable – all firms

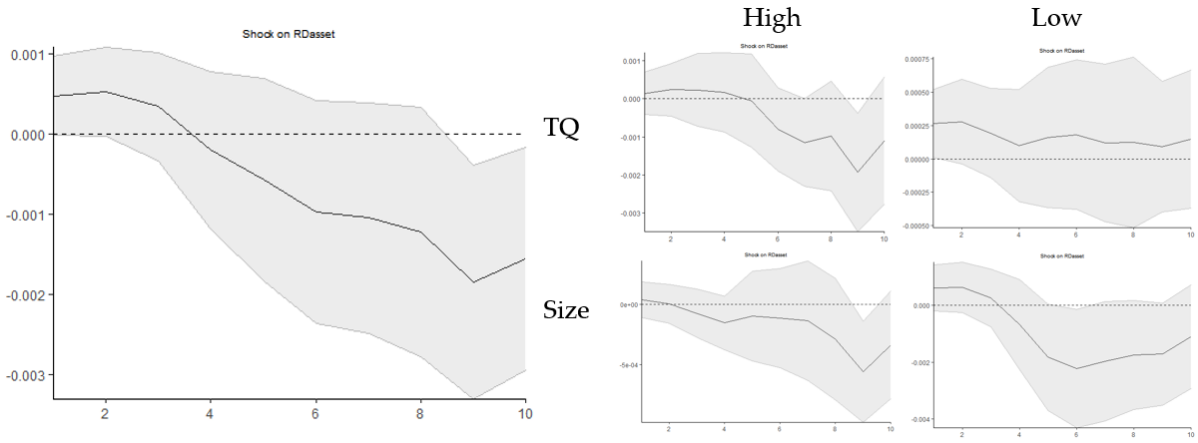
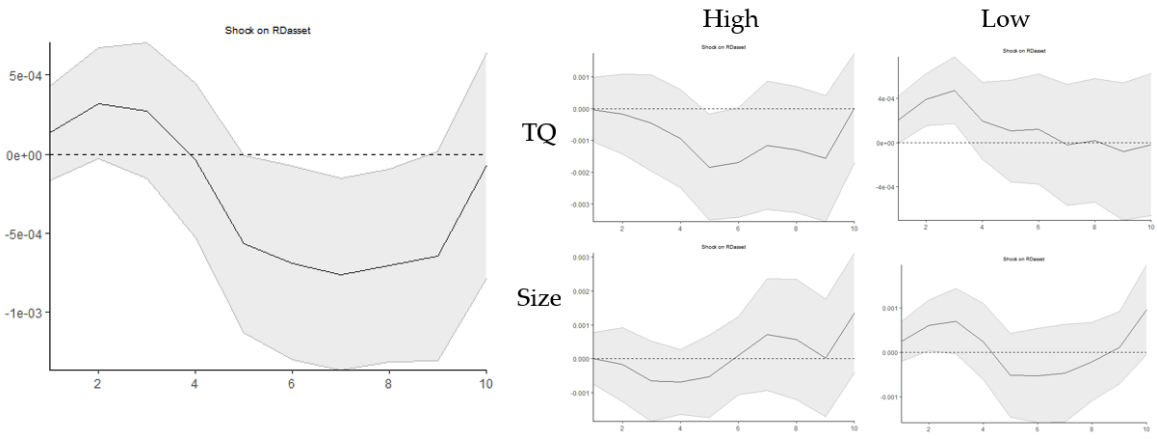


Figure 4. Impulse response to monetary shock with firm variable – all firms



Now I present the graphical representation of both *chaebols* and non-*chaebols* for the impulse of response of R&D investment to monetary shock in order to observe the effect of monetary policy rate change in detail. The Figure 5 and 6 illustrate the impulse response of R&D investment to monetary shock for *chaebols* without and with firm-specific variables controlled, respectively.

The Figure 5 shows gradually decreasing pattern of R&D investment to monetary shock across observation period. However, the patterns in all graphical representation including high and low Tobin's Q and firm size, do not show consistently decreasing pattern and even statistical significance is not found. The following Figure 6, with firm-specific variables controlled, samples demonstrate inconsistent pattern of R&D investment to the increase of monetary shock. Mostly, the increasing or decreasing patten of each sample is dependent upon Tobin's Q and firm size and statistical significance is not found across the samples. Interestingly, this pattern is in consistence with previous research (Kwon et al., 2018; Shin and Park, 1999) in that *chaebol*-affiliated firms do not rely on external financing for investment; rather they enjoy access to internal financing within affiliates so that would not drastically respond to the change of monetary policy rate.

Figure 5. Impulse response to monetary shock without firm variable – chaebol

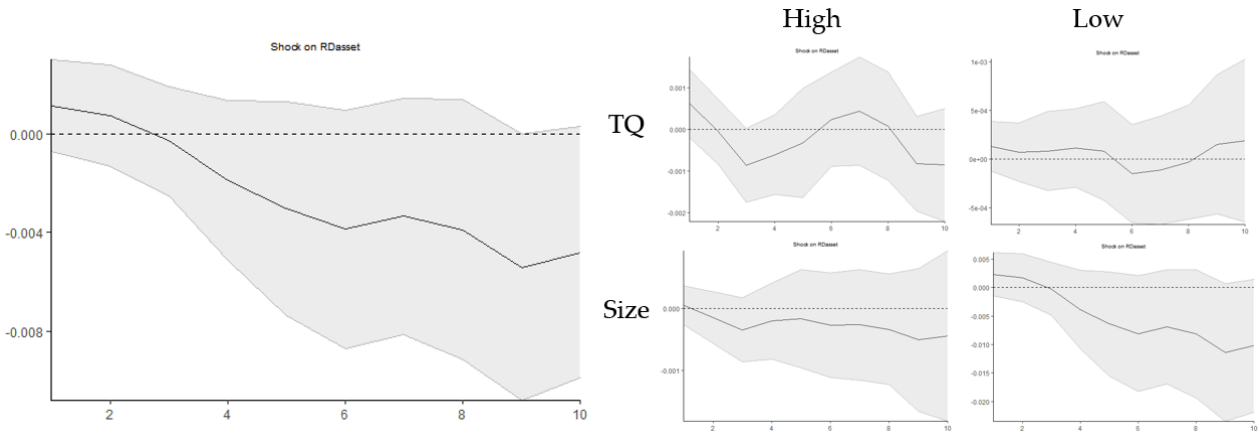
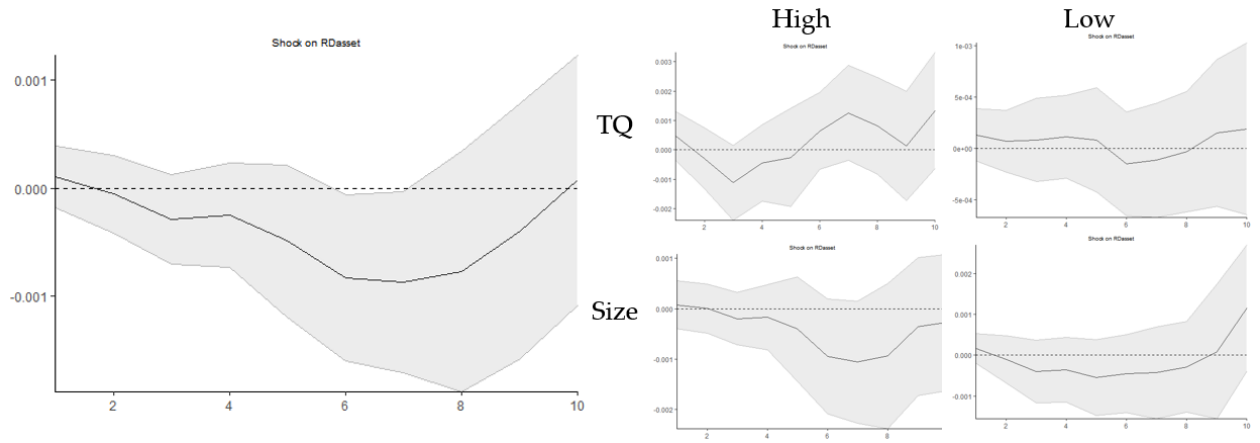


Figure 6. Impulse response to monetary shock with firm variable – chaebol



Lastly, I present evidence for impulse response of the R&D investment for non-*chaebols* to monetary shock in Figure 7 and 8, which are without and with firm-specific variables controlled, respectively. Although the gradual decrease of R&D investment is only found at statistically significant level for high Tobin's Q for the samples without the variables controlled. However, for the samples with firm-specific variables controlled, the gradual decrease of R&D investment is consistently observed for the main sample and samples with high Tobin's Q and firm size. Interestingly, the pattern of non-*chaebols* is consistent with the idea that that market uncertainty at firm level diminishes as firm size increases (Czarnitzki and Toole, 2011); in contrast, as aforementioned, there exists no statistically significant relationship of R&D investment and monetary policy shock for *chaebols* as represented in Figure 4 and 5.

Figure 7. Impulse response to monetary shock without firm variable – nonchaebol

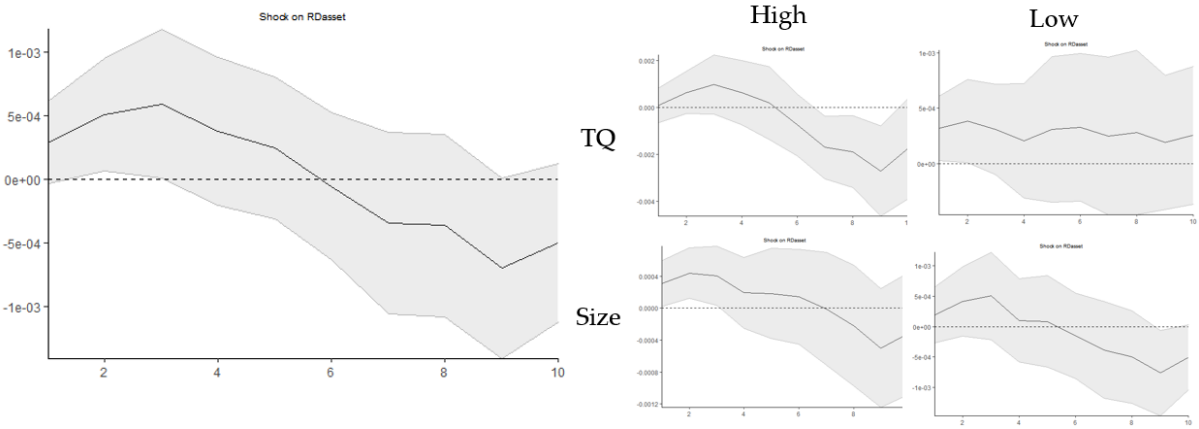
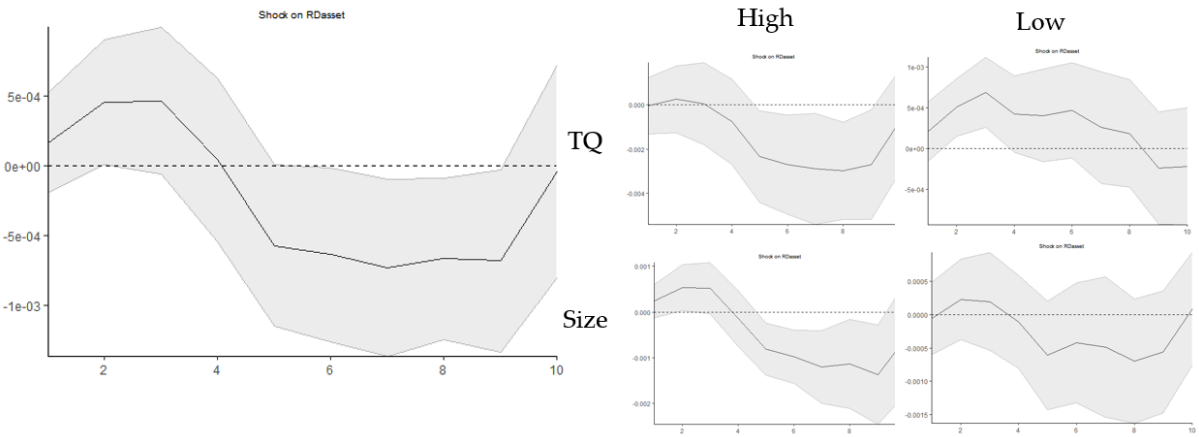


Figure 8. Impulse response to monetary shock with firm variable – nonchaebol



IV-2. Balance sheet channel

Then, I carry out same analysis for *chaebols* and non-*chaebols* based on the level of their leverage to verify the balance sheet channel. The following Figures 9, 10 and 11 represent the results for impulse response of R&D investment to monetary shock under three different category of firm samples – all firms, *chaebols* and non-*chaebols*. Similar to the analysis for the asset price channel, I carry out analysis based on leverage to verify the balance sheet channel. For example, I define 'high leverage' as the firms with the values of leverage which are larger than median value and vice versa. As well, I deliver the model without and with firm-specific control variables in Panel A and Panel B respectively.

Figure 9 illustrates the decreasing pattern of R&D investment of all firms for high leverage and low leverage without (Panel A) and with (Panel B) firm variables. While Figure 9 for all firms present the decreasing pattern of R&D investment in response to monetary policy shock in general, it is worthwhile to point out the different decreasing pattern of R&D investment between *chaebols* (Figure 10) and non-*chaebols* (Figure 11) in response to monetary policy shock.

Figure 9. Impulse response to monetary shock without (Panel A) and with (Panel B) firm variable – all firm

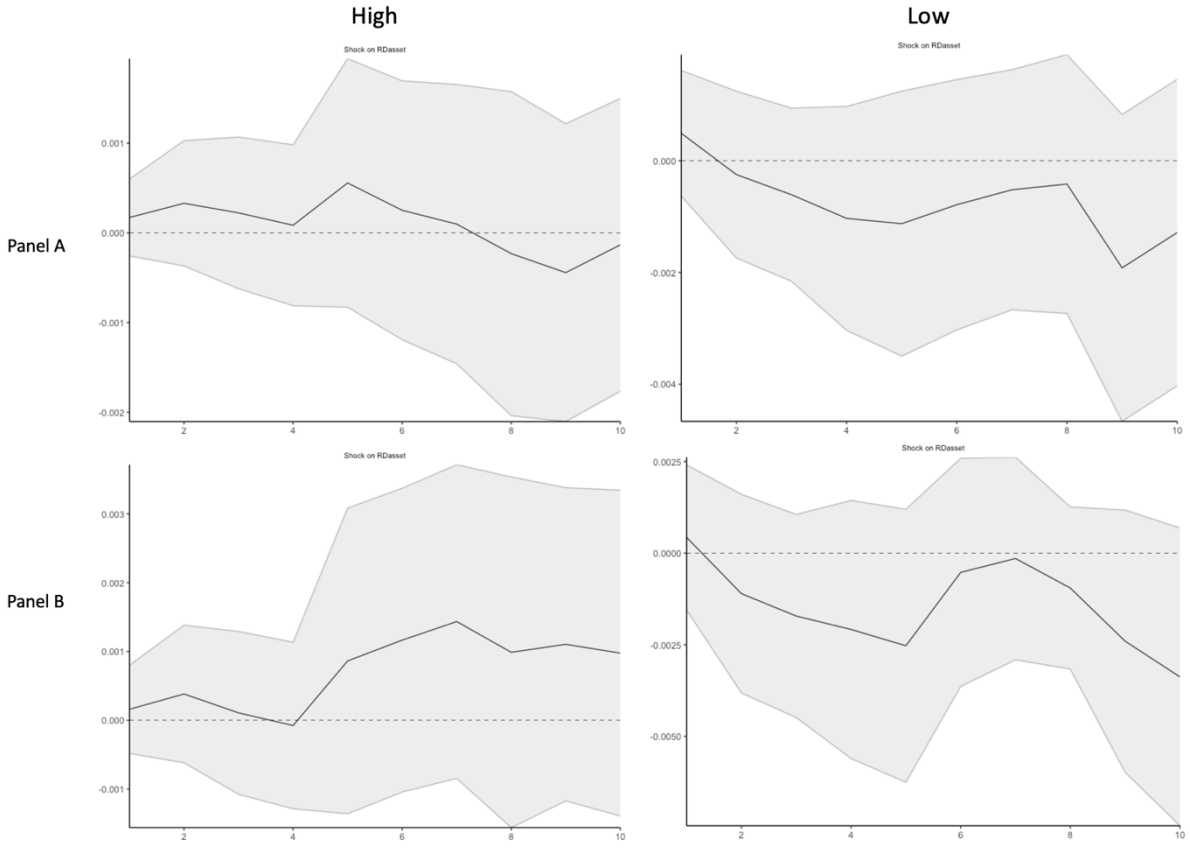


Figure 10. Impulse response to monetary shock without (Panel A) and with (Panel B) firm variable – chaebol

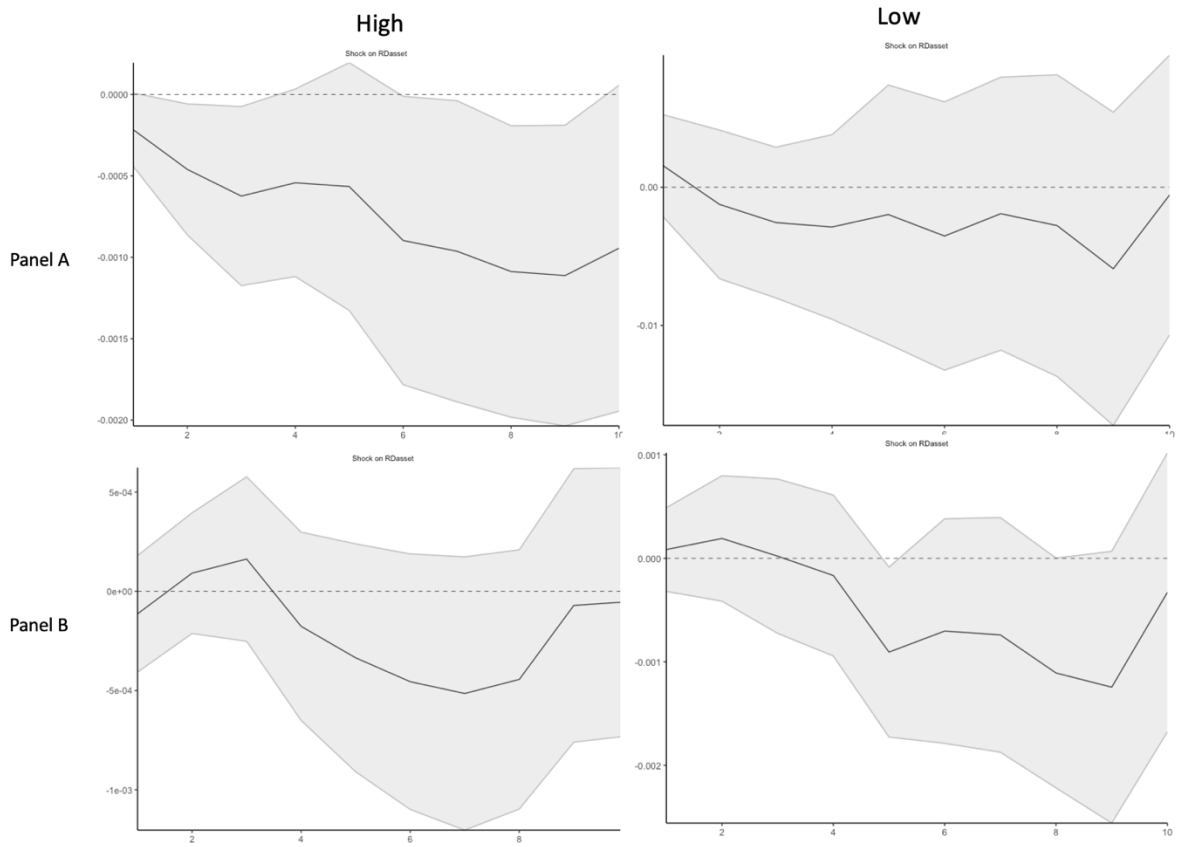
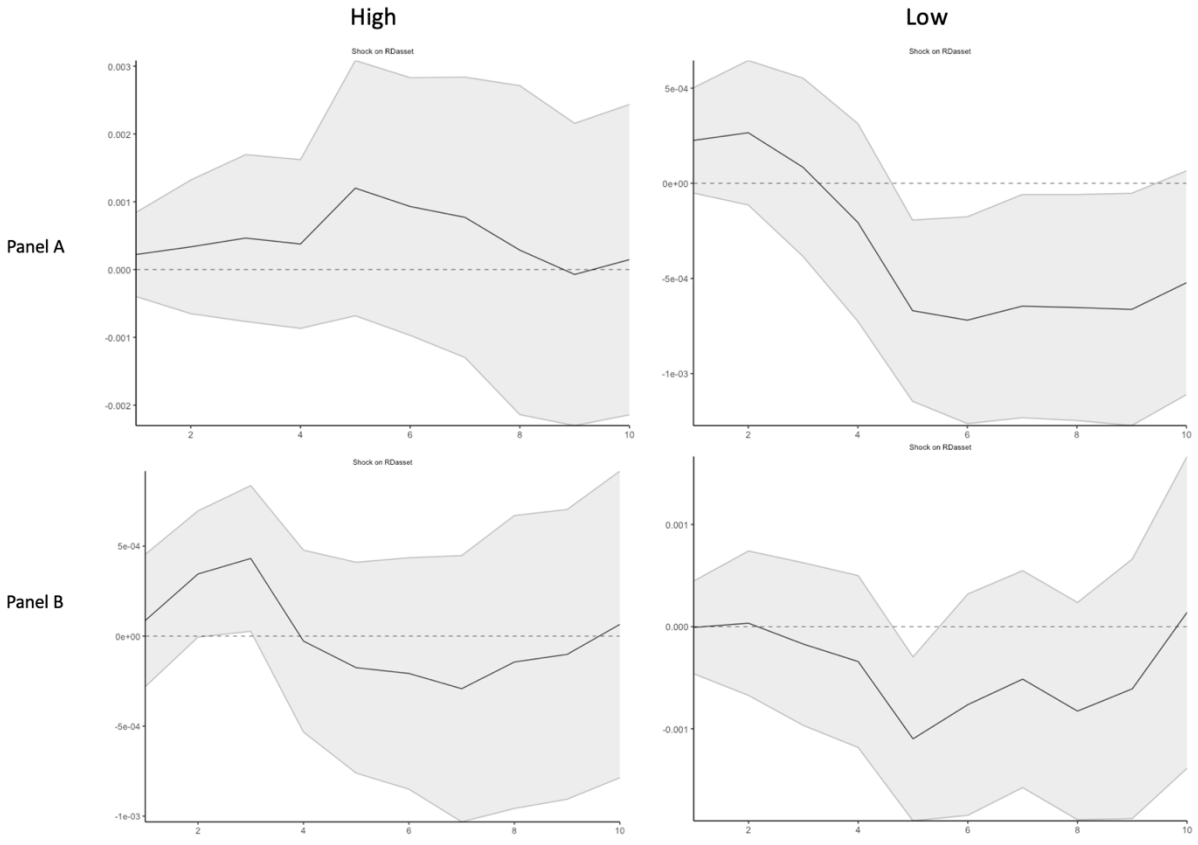


Figure 11. Impulse response to monetary shock without (Panel A) and with (Panel B) firm variable – nonchaebol



For example, Figure 10 shows that the R&D investment of *chaebol*-affiliated firms with "high leverage" firms in Panel A gradually decreases from 6th to 10th quarter at statistically significant level. This is evident in the analysis without firm-specific variables only. In contrast, Figure 11 presents the steadily decreasing pattern of R&D investment for non-*chaebols* with "low leverage", which is evidenced from 5th to 9th quarter at statistically significant level. However, the decreasing pattern of R&D investment for non-*chaebols* is only found around 5th quarter for the sample with firm-specific variables.

The contrasting pattern between *chaebols* and non-*chaebols* can be summarized as following. While the R&D investment in response to monetary policy shock steadily decreases for *chaebols* with "high leverage", the R&D investment decreases for non-*chaebols* with "low leverage", which captures different firm characteristics in response to monetary policy shock.

Ⅴ. Discussion

The economic implication of this research is as following. First the empirical results based on the asset price channel are in align with previous research on "firm size" (Czarnitzki and Toole, 2013; Gertler and Gilchrist, 1994). Particularly, the reduction of R&D investment for non-*chaebols* decreases at statistically significant level, in contrast with *chaebols*. This suggests that when firms are small and do not have better access to internal resources, they are more likely to reduce the level of R&D investment in response to monetary policy shock. Thus, it is reasonable to conclude that the analysis based on the asset price channel well captures the tendency of non-*chaebols* to recognize R&D investment as "sunk costs" (Ghossal and Loungani, 2000).

Second, the empirical results based on the balance sheet channel suggests that the decrease of R&D investment for *chaebols* and non-*chaebols* may depend on "the level of leverage". To be specific, the Figures 10 and 11 suggest a contrasting pattern between the *chaebols* and non-*chaebols* in their R&D investment to monetary policy shock. The analysis for *chaebols* with "high leverage" demonstrate their inclination to the reduction of R&D investment, while the analysis for non-*chaebols* with "low leverage" suggest their tendency to decrease R&D investment in the response to monetary policy shock. In my analysis, the results for non-*chaebols* also align with previous finding in that although their leverages are generally lower than *chaebol*-affiliated firms, they are "more financially constrained and heavily dependent on internal cash flow to finance projects" (Shin and Park, 1999) for their small firm size.

As well, it is worthwhile to note that the level of R&D investment for non-*chaebols* with low leverage is comparatively higher than the ones with high leverage. For example, in my sample, the average value of the R&D investment (scaled by total asset) for non-*chaebols* with "low leverage" is 0.008, which is quite higher than the same value (0.006) for non-*chaebols* with "high leverage". Thus, it is plausible to suggest that the capacity for R&D investment for non-*chaebols* with low leverage is well captured in my analysis for the balance sheet

channel. This implies that the cost for the option to reverse the decision (Trigeorgis, 2002) becomes expensive for non-*chaebols* with low leverage.

VI. Conclusion

In this research, I focus on how R&D investment of Korean firms react differently to monetary policy shock through the lens of the asset price channel and the balance sheet channel. I separate firm samples into two different categories – *chaebols* and non-*chaebols* – to confirm if unique characteristic that originate from Korean business atmosphere, determines their tendency to increase or decrease R&D investment. For the analysis, I add firm-specific conditions such as Tobin's Q, asset volume and leverage, in order to examine the response of monetary policy in detail.

My major findings are as following. First, Korean firms in general tend to reduce the investment for R&D. This trend has strengthened for non-*chaebols* which do not enjoy internal financing unlike their counterpart, *chaebols*. Second, I find that in asset price channel, the R&D investment of firms with high Tobin-Q and asset volume are more responsive to monetary shock than the ones with low Tobin-Q, which is consistent with notions that firm-level market uncertainty on R&D investment diminish as the size of firm increases (Cho and Lee, 2021; Czarnitzki and Toole, 2013). Third, I find that in balance sheet channel, the R&D investment for non-*chaebols* with low leverage steadily increase, in contrast with *chaebols* in which firms with high leverage experience the decrease in R&D investment.

My study makes several contributions. First, I add to the growing literature on monetary policy and R&D investment in emerging market by addressing key firm-specific and macroeconomic variables which are unique to Korean firms. Second, I extend prior research by identifying Tobin's Q and firm size as key factors in determining the relationship of monetary policy shock and R&D investment. Third, I identify different characteristics of *chaebols*, unique conglomerates in Korea and non-*chaebols* by separately analyzing them through the asset price channel and balance sheet channel.

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