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Reserve Accumulation and Firm Investment: Evidence from Matched Bank–Firm Data

Woo Jin Choi, Korea Development Institute
Ju Hyun Pyun, Korea University Business School
Youngjin Yun, Bank of Korea

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Woo Jin Choi† Ju Hyun Pyun‡ Youngjin Yun§

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Abstract

We match non-financial firms in Korea with their main banks for the period over 2003-2017 to examine whether and how corporate investments are affected by changes in international reserves. We first show that firm investment is negatively associated with international reserves. By tracing the public securities used for sterilization, we further show that investment of a non-financial firm reduces if its main bank increases public securities holdings in accordance with reserve accumulation. Massive supply of sterilization securities shifts banks' balance sheet composition and adversely affects investments, especially for financially constrained firms. (*JEL*: C23, E22, E58, F21, F31)

Keywords: FX reserves, sterilized intervention, firm investment, bank balance sheet

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†Korea Development Institute, Namsejong-Ro 263, Sejong ,Korea, 30149. (wooj.choi@gmail.com).

‡Korea University Business School, Anam-Ro 145, Seongbuk-Gu, Seoul, Korea, 02841. (jhpyun@korea.ac.kr).

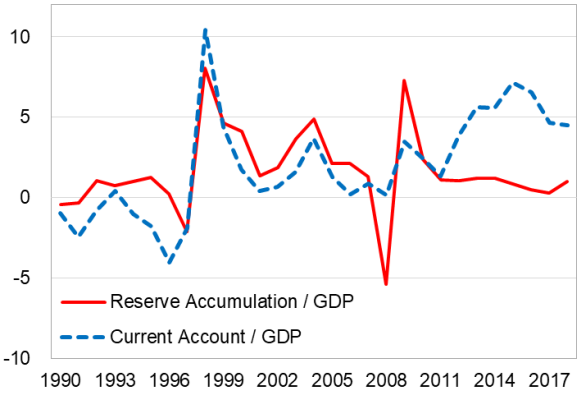
§Bank of Korea, Namdaemunno 39, Jung-gu, Seoul, Korea, 04531. (youngjin@bok.or.kr).

The massive accumulations of international reserves is one of the most striking phenomenon in external economic policy over the past few decades. Arguably, this accumulation has been a major driver of the global imbalances, especially before the Global Financial Crisis (GFC). Reserve accumulation constitutes an essential building block of the flexible inflation targeting framework that was adopted and developed by many emerging market economies (BIS, 2019). Along with the heightened vulnerability that followed on the capital account liberalization of the 1990s, the unconventional and presumably ineffective exchange rate policy has now become one of the most popular policy tools of central banks, in emerging as well as in advanced economies. Despite its prevalence, however, the operational effects of the accumulation on the real economy (e.g., firms), especially the effect of it changing financial intermediation, have not been fully explored.

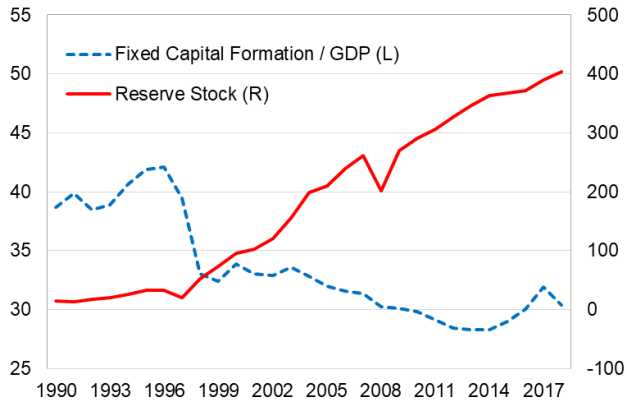
From the simple accounting identity, $S - I \equiv CA \equiv FA$, the gap between saving (S) and investment (I) equals to the financial account (KA) which records net capital outflows. If the flows in financial accounts are driven mostly by public capital outflows (reserve accumulation), and if aggregate saving cannot move in tandem, then it is apparent that the investment has to be substituted. Korean cases serve as a good example of this relationship. The left panel of Figure 1 plots Korean current account (CA) together with reserve accumulation as percentages of GDP. During its massive reserve accumulation period, from around 1998 to 2011, reserve accumulation closely tracked the CA surplus. Hence, for Korea during this period at least, the capital outflows (FA) has been driven by reserve accumulation. The size and direction of reserve accumulation is carefully determined by central bank and government officials. Therefore one may enquire about the dynamics on the other side of the equation ($S - I$), especially the investment. The panel on the right shows the fixed capital formation to GDP ratio, along with reserve stock. The downward investment trend which began after the 1997 Asian financial crisis coincides with the increasing international reserve trend.

Figure 1: *International reserves and macro aggregates*

(a) Reserves and current account



(b) Reserve stocks and fixed capital formation



Notes: This figure shows the relationship between international reserves and macro variables such as current account and fixed capital formation for the period 1990 to 2017. The left panel plots the ratio of reserves to GDP and the current account to GDP. The unit is percentage in the left panel. The right panel draws reserves stocks and a ratio of fixed capital formation to GDP. Capital formation ratio is on the left axis, and the unit is percentage. Reserve stocks use the right axis, and the unit is billion U.S. dollars. Data are sourced from the Bank of Korea.

We find from the 1994-2017 sample of Korean firms that firm investment rates decrease with reserve accumulation. In particular, firms with higher shares of short-term debts in their assets reduce investment more. The novel feature of this study is that we introduce matched bank–firm data (from 2003 to 2017) to identify the channel through which reserve accumulation affects banks' balance sheets, thereby firms' external financing and investment. We find that firms reduce investment as their main banks increase sterilization securities holdings after reserve accumulation, and that the decrease is more pronounced for highly leveraged firms. The aforementioned effects mostly come from non-exporters rather than from exporters, and from non-listed firms instead of from listed firms.

While previous studies document the negative relationship between reserve accumulation and investment, this study is the first to provide micro level evidence of causation from matched bank–firm data. Reinhart *et al.* (2016) investigate macro variables of the

Asian economies and document the negative correlation between investment and reserves. They define the terminology, *central bank crowding-out*, for the possible substitution of reserve accumulation with investments. Central banks' purchases of foreign exchange are sterilized in most cases. Sterilized intervention is essentially an exchange of public securities with foreign exchange liquidity in the market. After reserve accumulation, the liquidity shrinks which might have been flowed to firms otherwise. Firms may find it more difficult to fund their investment; hence, crowding-out happens. Yun (2020), indeed, finds evidence from Korean bank level data that reserve accumulation reduced bank lending. Similarly, Hofmann *et al.* (2019) find that sterilized reserve purchases dampen the flow of new corporate loans in Colombia. However, no study has yet provided micro-evidence how reserves influence firm investment via financial intermediaries. This paper fills this gap by constructing matched bank–firm data, and examines how individual firm level investments are affected by reserve accumulation.

We use a multi-layered strategy to correctly identify the effect of reserve accumulation from firm investment fluctuations. First, we investigate a specific mechanism of central bank crowding-out and deploy two-stage regressions. A major channel of reserve accumulation affecting firm investment would be through bank credit. Previous studies found that reserve accumulation reduces the bank loan supply to firms (e.g., Hofmann *et al.*, 2019; Yun, 2020). Going further we examine whether the reduced loan supply influences firm investment negatively. We match each firm with the balance sheet of its main bank, and test whether the bank's absorption of sterilization securities, which results from reserve accumulation, is related with matched firms' investment. At the first stage, we estimate the amount to which the banks increase sterilization securities holdings due to reserve accumulation. We regress banks' holdings of the securities on reserve accumulation with bank fixed effects. Then in the second stage, we use the predicted changes in banks' sterilization bond holdings as a firm level shock in the investment regressions. The procedure captures the corporate investment effect of bank asset composition changes

initiated by the reserve accumulation. This two-stage procedure we use is similar with the IV estimation of Cingano *et al.* (2016) who estimate the effect of banks' exposure to interbank market collapse on the matched firms' investment which happens through reduced credit supply.

In addition, we deploy differences-in-differences framework similar with Kalemli-Ozcan *et al.* (2018), and use bank-time fixed effects. There is a large heterogeneity in firms' indebtedness. If reserve accumulation reduces available funds for the firms, the effects should vary among firms with different pre-existing debts. Firms with high levels of short-term debts would find it more difficult to fund their investment after central bank absorbed liquidity from the firm's main bank. However, firms with lower levels of short-term debts may find less difficulty in financing their investment. Hence, we compare investment of firms with different levels of pre-existing debts after different sizes of reserve accumulation. The high dimensional data and differences-in-differences scheme allow us to use bank-time fixed effects. The fixed effects control for the changes in macroeconomic environment common to all firms as well as for any unobserved idiosyncratic shocks on individual banks, thereby playing a crucial role in eliminating endogeneity concerns.

This paper contributes to the reserve accumulation literature by presenting micro level evidence of investment crowding-out. The literature is mainly focused on the motivation and benefits of reserve hoarding,[1] and a small group of cost-related studies concentrates on the fiscal cost (i.e., carrying cost) of reserves.[2] While the literature is scarce on domestic consequences of reserve accumulation, a few studies question whether reserve management can affect domestic financial intermediation and investment. Observing

[1] Although there is still significant disagreement on the quantification of benefits, the literature has narrowed it down to a couple of key motivations of reserve accumulation: precautionary motive (Durdu *et al.*, 2009; Jeanne and Ranciere, 2011) and mercantilist motive (Dooley *et al.*, 2004; Korinek and Serven, 2016). Lee *et al.* (2020) quantify each motive in reserve accumulation using a small open economy model. Another strand relates the international reserves to an "internal drain" (domestic financial instability or bank runs) (e.g., Obstfeld *et al.*, 2010; Bocola and Lorenzoni, 2020), and examines the liquidity role of reserves in attracting foreign investments in emerging markets (e.g., Jung and Pyun, 2016).

[2] See, for example, Calvo (1991), Rodrik (2006), Yeyati (2008), Adler and Mano (2018).

negative correlations of reserve accumulation and aggregate investment, Reinhart *et al.* (2016) assert that reserve accumulation can crowd-out investment. Lee and Choi (2010) and Cook and Yetman (2012) raise similar questions using international panel data and a simple theoretical model. More recently, Hofmann *et al.* (2019) and Yun (2020) came up with evidence at a micro-level that reserve accumulation negatively affects bank loan supply. However, they do not get to the firm level outcomes of reserve accumulation. We contribute to this literature by providing further investigation on the real effect.

Methodologically, this paper relates to the growing literature using matched bank–firm data. Since the seminal work by Khwaja and Mian (2008), many studies utilized matched bank–firm data to identify credit supply shocks. For instance, Schnabl (2012) analyzes the effect of an exogenous external financial shock on bank credit supply; Jiménez *et al.* (2012) study the bank lending channel of monetary policy; Baskaya *et al.* (2017) analyze the effect of capital inflows on local credit supply; and Amiti and Weinstein (2018) investigate the effect of bank idiosyncratic shocks on their credit supply. All these papers exploit three dimensional data (bank–firm-time) to include firm-time fixed effects which erase credit demand fluctuations. One major demerit of this method, however, is that it utilizes multi-bank firms only from the data. The observations of single-bank firms are completely absorbed by the fixed effects. Typically, small firms tend to borrow from single bank, and bank credit supply behavior differs for single-bank firms and multi-bank firms (Cahn *et al.*, 2020). Hence, dropping out single-bank firms could lead to selection bias in certain circumstances. In this study, we construct a new dataset that matches 22,384 non-financial firms with their main banks. The sample consists of many small firms. The Khwaja and Mian estimator is not feasible in our dataset since we match one bank for each firms, but the estimator is also not appropriate in our case because small firms are important in the channel we examine. Instead, we utilize the high dimensionality of the data by including bank-time fixed effects which control for individual bank level credit supply shocks and reduce endogeneity concerns significantly. In the end, we find the effect under our study

come mostly from the small firms (non-listed, non-exporting) which are more likely be a single-bank firm.

The remainder of this paper is organized as follows. The next section describes the data, and shows how the matched bank–firm data is constructed. Section 2 documents our first empirical results. We show results from the firm-level analysis for the longer sample period 1994-2017. Section 3 presents the main empirical results. We make use of the main banks' balance sheet information to delve into the mechanism. In section 4, we do several sub-sample analyses and robustness check. Finally Section 5 concludes.

1. Data

We analyze data from Korea for this study. The Korean case provides a unique opportunity to examine the relationship between reserve accumulation and investment. As of 2017, the end of our sample period, Korea is a top 10 holder of FX reserves (389 billion USD) in the world. As it is shown in the Figure 1, the reserve stock of Korea increased rapidly over the last couple of decades. Until the GFC, the accumulation was sufficiently significant to dominate the current account.

We combine firm balance sheets with bank balance sheets at the annual frequency by matching each firm with its main bank. The firm level data come from the Nice Investors Service. All firms larger than a certain size,[3] are subject to annual external audits, and are mandated to disclose balance sheet information. The Nice Investors Service collects those data from the Financial Supervisory Service, and provides them to researchers. We note, however, that the information on the firms' main bank, the key to link banks and firms, are not provided in a time-series. Thus, we had to merge snapshot of the Nice data of each year manually. We exclude financial firms, but include closed firms. As our baseline analysis involves dynamic specification, we drop firms with single observation during

[3]The threshold changes intermittently, but is approximately similar to the size of 100 employees.

the sample period from 1994 to 2017. This yields a sample of 22,384 firms in total.

The bank balance sheet data are obtained from the Financial Analysis Information Retrieval System (FAIRS) of the Bank of Korea. FAIRS provides more detailed balance sheet information than publicly available data. In particular, we obtain the information on each bank's holding of government bonds and the Monetary Stabilization Bond (MSB), the sterilization bond issued by the central bank. Since the bank data do not reflect the period before 2003, however, the analysis on the matched sample is done for the period 2003-2017 which still encompasses major reserve accumulation period for Korea.

Table 1 provides descriptive statistics on both the full sample (1994-2017) and the matched sample (2003-2017). The shock analyzed in this paper is reserve accumulation. We measure strength of reserve accumulation by the reserve accumulation-to-GDP ratio. The accumulation data come from the official balance of payment statistics. It excludes the valuation effect of accumulated reserve stocks and records transaction components only. The size of annual reserve accumulation is, then, normalized by GDP. Average annual accumulation over the sample period is 1.9 percent of GDP. The sample period is 24 years, but there are closed firms and newly established firms during the period, and hence median number of observation per firm is 9. Investment rate, the main regressand of this study, is measured as the annual change in fixed tangible assets ($\Delta K_t / K_{t-1}$). The current liability is short-term debt with maturity less than a year. Other covariates include leverage (liability over total asset ratio), cash flow to asset ratio, sales growth, log asset size, and interest paid to EBITA ratio. As shown in the table, the standard error associated with investment rates is large. In the regression analysis, we winsorize top and bottom three percent of the investment rate to control for outliers. For the other covariates, we winsorize top and bottom one percent.

The matched data have a shorter sample period of 15 years (2003-2017). We exclude an exim bank and a development bank which are directly managed by the government. Hence, firms with those two banks as main bank are dropped. Firms with single

Table 1: *Descriptive statistics*

Full sample: 1994-2017	N	mean	St.Dev.	p25	median	p75
number of firms	22,384					
reserve accumulation to GDP	24	0.02	0.03	0.01	0.01	0.03
number of observations per firm	141,728	9.48	5.30	5	9	13
investment ratio	141,728	0.17	0.68	-0.07	-0.02	0.15
current liability to assets	141,728	0.43	0.20	0.27	0.42	0.57
leverage	141,728	0.61	0.22	0.44	0.62	0.77
cashflow to assets	141,728	0.10	0.08	0.04	0.08	0.14
sales growth	141,728	0.09	0.27	-0.05	0.06	0.20
(log) asset size	141,728	17.07	0.88	16.40	16.87	17.60
interest paid-EBITA	141,728	0.26	0.31	0.07	0.18	0.35
Matched sample: 2003-2017	N	mean	St.Dev.	p25	median	p75
number of firms	14,364					
reserve accumulation to GDP	15	0.02	0.03	0.01	0.01	0.02
number of observations per firm	73,438	7.03	3.55	4	7	10
investment ratio	73,438	0.17	0.66	-0.07	-0.02	0.15
current liability to assets	73,438	0.42	0.20	0.27	0.41	0.57
number of banks	27					
Δ public bonds to assets ($\times 100$)	217	0.55	3.68	-0.86	0.21	1.50
central bank security to assets	25	4.21	5.65	1.06	2.38	3.60
number of firms switching main banks		total	none	once	twice	3 <
including bank M&A		14,364	11,042	3,033	269	20
excluding bank M&A		14,364	12,676	1,576	108	4

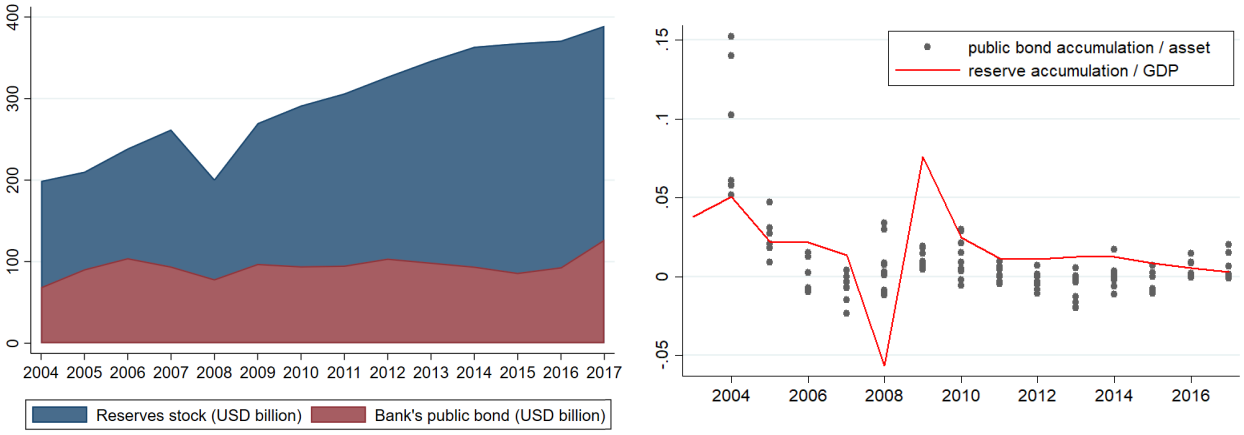
Notes: This table reports summary statistics of all variables in the dataset. The data are twofold; The upper panel shows firm level data from 1994 to 2017 and the middle panel displays bank–firm matched sample from 2003 to 2017. We also report the relationship between firms and their main banks. About 95% firms keep thier main banks or switch the banks only once. Note that reserve accumulation is the transaction record obtained from the balance of payment.

observation during this period are also dropped, and so the number of firms shrinks to 14,364. After all, firms are matched with 27 banks in this sample. Banks are treated as different entities in cases of merger and acquisitions. The average share of the central bank security in the sample banks' balance sheets is 4.21 percent while the average annual growth rate of the public bonds, which also includes government bonds, is 0.55 percent of the bank's asset. While the majority of the firms sticks to one bank for the main bank, other firms occasionally switch to different main banks. Out of 14,364 firms, around 3,000 firms changed their main bank once over this 15 year period. Excluding the unavoidable cases due to bank mergers and acquisitions, more than one percent (1,688 firms) still changed banks at least once.

We identify a channel of macro shocks delivered to firm-level outcome through changes in bank balance sheets. We can get hints of the linkage from a set of graphs before we get into the regression analysis. Figure 2 shows the relationship between

Figure 2: *International reserves and banks' public bond holdings*

(a) Reserve stocks and public bond holdings (b) Reserve-to-GDP and bond holdings-to-assets

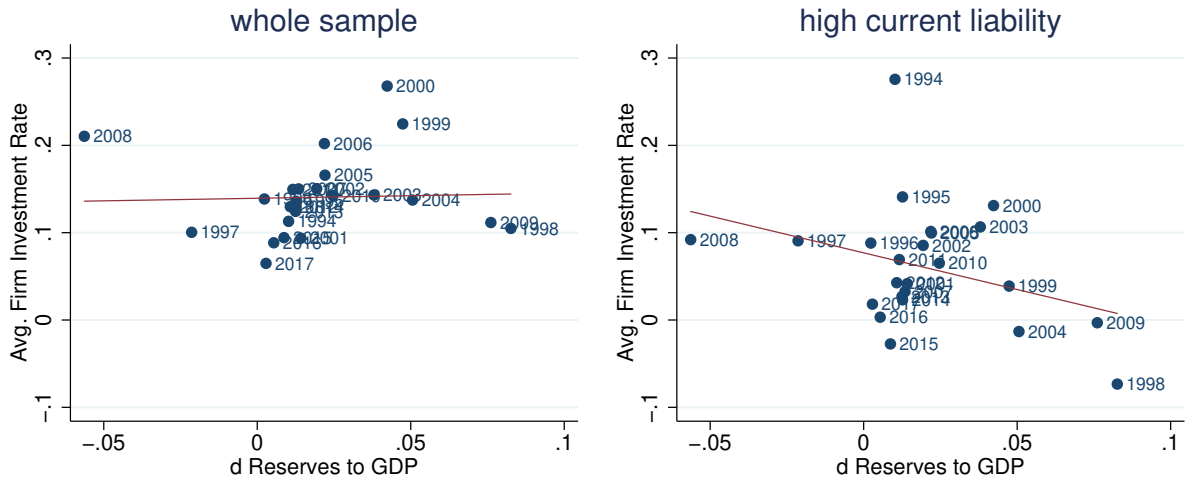


Notes: This figure shows a linkage between reserves accumulation and bank's public bonds holdings. The left panel shows the pattern in reserves stock and total public bonds amount held by all banks in our sample from 2004 to 2017. The unit is current USD billion in the left panel. The right panel plots scaled reserves (reserves to GDP ratio) and individual banks' public bond holdings to total assets (dots). The unit is a percentage. Data sourced from the Bank of Korea.

reserve accumulation and public bond holdings by the commercial banks. Panel (a) shows the stock of reserves with the stock of public bond held by the banks in our sample. The banks' public bond holdings account for about 40% of reserve stocks constantly over time, and it moves in the same direction with reserves. The red line in panel (b) shows annual reserve accumulation scaled by the GDP. Individual banks' annual public bond accumulation scaled by the banks' total assets are plotted with grey dots. By and large, the dots are scattered around the line. Reserve accumulation has a significant influence on bank balance sheets.

The next graphs, Figure 3, shows tentative evidence for our differences-in-differences scheme. For each year in the sample period, we obtain average investment rates and plot it with the reserve accumulation-to-GDP ratio of that year. The investment rate of the left panel is averaged over the entire firms, while that in the right panel is averaged over the firms with top 5 percentile leverage (current liability to asset ratios). We do not find any correlation between investment and reserve accumulation in the whole sample, and

Figure 3: *Reserve accumulation and average investment rate*



Notes: The figures are scatter plots of the mean investment rates ($\Delta K_t / K_{t-1}$) and reserve accumulation-to-GDP ratios. The vertical axis is the investment ratio. For each year during the sample period (1994-2017), we calculate mean investment ratios for the whole sample (left panel) and for the firms with the top 5 percentile short-term debt-to-asset ratio (right panel). Simple linear regression lines are plotted together. Top and bottom 3% of investment ratios are winsorized.

the fitted line is slightly positive sloped. However, for the highly indebted firms, we see that investment rates tend to be lower for the years with larger reserve accumulation. The next section examines the differences in investment ratios of differently indebted firms after different sizes of reserve accumulation.

2. Results from Full-Sample Firm Data: 1994-2017

We first analyze the full sample data with a longer time span (1994-2017) but without bank information. The identification here primarily relies on comparing investment of firms with the different short-term debt ratios after reserve accumulation. If reserve accumulation makes it more difficult for firms to fund their investment, it should be more so for the firms that are highly indebted to begin with. We thoroughly examine the change in firm investment after reserve accumulation with regressions. Below is the baseline specification.

$$\texttt{INV}_{i,t} = a_i + a_t + \rho \texttt{INV}_{i,t-1} + \delta \texttt{CL}_{i,t-1} + \beta \texttt{CL}_{i,t-1} \times \Delta \texttt{RSV/GDP}_t + X'\gamma + \epsilon_{i,t} \qquad (1)$$

INV is a tangible capital growth rate. a_i and a_t are firm fixed effects and year fixed effects, respectively. As is typical in investment regressions, we include a lagged regressand. CL is the current liability-to-assets ratio. We interact CL with ΔRSV/GDP, a ratio of reserve accumulation to GDP. The current liability ratio is lagged by one year to avoid endogeneity. We are mostly interested in the coefficient β, and expect it to be negative. All individual terms of an interaction term should be included together in the regression. Note that the ΔRSV/GDP term is absorbed by the time fixed effects. X is a vector of other standard control variables: leverage, cash flow to asset ratio, sales growth, log asset size, interest paid to EBITA ratio, and also a linear time trend. Control variables are also lagged by one year.

Table 2 presents the results. First, Columns (1)-(3) present panel OLS for the benchmark. In Column (1), we check how reserve accumulation is associated with firm investment in general. For that we do not include time fixed effects. The coefficient on reserve is negative and significant at the 1% level (=-0.2447). It means that firm investment ratios decline by 0.25 percentage points in response to a one percentage point increase in the reserve accumulation to GDP ratio. This is comparable to a 1.4% decrease from the mean of the investment ratio, 17% (=0.17). The coefficient to the current liability ratio is positive reflecting the fact that firms finance investment mostly from short-term borrowing, as documented by Kalemli-Ozcan *et al.* (2018). All other control variables show the expected signs. Column (2) adds the interaction term, and Column (3) adds time fixed effects to control for any common factors in a year, distinguished from the reserve change. The interaction term is negative and significant, meaning that highly indebted firms reduce investment more after reserve accumulation. The result on the interaction term becomes more significant after including time fixed effects while the reserve variable is soaked up by the fixed effects (Column 3).

The regressions so far include both firm fixed effects and a lagged regressand, but neglect to address the Nickell bias (Nickell, 1981). Next, we consider the GMM specification to correct for the bias. Column (4) reports the results using difference GMM, and Column (5) report those using system GMM. The interaction term remains negative and significant in both columns, implying that the reserve effects on firm investments vary with the levels of leverage. The interquartile range of current liability-to-asset ratio is 0.3; hence, the interaction term coefficient -1.09 in Column (5) indicates that the top 75 percentile current liability firms reduce investment rates by 0.33 percentage points more than the 25 percentile firms, in response to an increase in the reserve accumulation to GDP ratio by one percentage point.

We conduct a weak instrument variable (IV) test and an over identification restriction test to confirm the reliability of the GMM estimators. In Columns (4) and (5), we reject

Table 2: *Reserve accumulation and firm investment*

	(1)	(2)	(3)	(4)	(5)
Dependent variable : $INV_{i,t}$	Panel OLS	Panel OLS	Panel OLS	Difference GMM	System GMM
$INV_{i,t-1}$	-0.0362***	-0.0361***	-0.0366***	-0.0004	0.0591***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
$\Delta RSV/GDP_t$	-0.2447***	0.1959			
	(0.063)	(0.147)			
$\Delta RSV/GDP_t \times CL_{i,t-1}$		-1.0426***	-1.2068***	-0.8015**	-1.0856***
		(0.338)	(0.338)	(0.378)	(0.345)
$CL_{i,t-1}$	0.1872***	0.2048***	0.2159***	0.5230***	0.2446***
	(0.018)	(0.019)	(0.019)	(0.030)	(0.012)
$Leverage_{i,t-1}$	-0.2993***	-0.2997***	-0.3038***	-0.6584***	-0.2476***
	(0.019)	(0.020)	(0.021)	(0.048)	(0.012)
Cash flow/$Assets_{i,t-1}$	0.1516***	0.1518***	0.1274***	-0.1103***	0.1757***
	(0.029)	(0.029)	(0.029)	(0.035)	(0.027)
Sales $growth_{i,t-1}$	0.0756***	0.0757***	0.0760***	0.0601***	0.0526***
	(0.007)	(0.007)	(0.008)	(0.009)	(0.007)
$Size_{i,t-1}$	-0.2052***	-0.2050***	-0.2105***	-0.9636***	-0.0494***
	(0.006)	(0.006)	(0.007)	(0.020)	(0.002)
Int. paid to $EBITA_{i,t-1}$	-0.0620***	-0.0615***	-0.0887***	-0.0499***	-0.0860***
	(0.009)	(0.009)	(0.009)	(0.013)	(0.007)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	Yes	Yes	Yes
Weak IV test (p-value)				0.00	0.00
Hansen's over id (p-value)				0.00	0.46
AR(1)/AR(2)				0.00/ 0.396	0.00/ 0.21
# of instruments				51	54
# of firms	20,099	20,099	20,099	14,099	20,099
Observations	90,134	90,134	90,134	59,375	90,134
R-squared	0.258	0.258	0.266		

Notes: This table shows the effect of reserve accumulation on firm level investment. The dependent variable is the firm-level investment rate ($INV_{i,t-1}$). $\Delta RSV/GDP_t$ is a change in the reserves to GDP ratio at t. $CL_{i,t-1}$ is firm-level current liability to assets ratio. We control for factors that influence firm-level investment that previous studies specified. The sample period is 1994-2017. Columns (4) and (5) report two-step GMM results for the dynamic panel model. Clustered standard errors at firm level are reported in the parentheses. *, **, *** means significant at the 10%, 5%, and 1% level, respectively.

the null hypothesis that instruments are weak. While the difference GMM results in Column (4) reject the validity of instruments, the system GMM results do not reject the over identifying restrictions, suggesting that the instruments are valid in our preferred results of the system GMM. Last, it is necessary to check whether the error term is serially correlated; if it is not correlated, then the first-order differenced error terms are expected to have serial correlation (AR(1) test). Then, it is expected that the second order differenced error terms will have no serial autocorrelation (AR(2) test). We report the test results for the first and second order autocorrelation in the differenced error terms, which support the validity of dynamic specifications.

Overall, the results corroborate the central bank crowding-out effect (Reinhart *et al.*, 2016). Sterilized reserve accumulation reduces available credit to firms, so it can negatively affect investment. In Table 2, we find that firms reduce investment after reserve accumulation, and that the effect is more pronounced for firms with high levels of short-term debt to assets. Short-term debts in firm balance sheets are mostly bank loans. The results are in line with the findings of previous studies that banks reduce loan provision to firms after reserve accumulation. When banks are short of liquidity after sterilized reserve accumulation, they would be less willing to increase loan provision to firms with already high-level of loans. The results imply that banks limit credit to those firms more in times of reserve accumulation. In the next section, we delve more into this specific mechanism for a more concrete verification of causation.

3. Results from Matched bank–firm Data: 2003-2017

The previous section finds that firm investments decline after reserve accumulation, and that the effect is larger for firms that have a larger share of short-term debt in their balance sheets. The results imply that financing investment becomes more difficult after reserve

accumulation. We posit that it happens through banks that reduce the loan supply after assuming sterilization bonds. In this section, we match each firm i with its main bank j to examine the mechanism.

With the matched bank–firm dataset, we conduct two stage regressions. First, we measure reserve accumulation-induced changes in banks' holdings of sterilization bonds by regressing banks' public bond holdings on reserve accumulation. Second, we use the predicted changes in banks' public bond holdings as a firm-level reserve accumulation shock, and examine its impact on the firm's investment. Specifically, the first stage regression equation is:

$$\Delta \texttt{sterilization\_bond}_{j,t}/\texttt{asset}_{j,t-1} = \alpha_j + \beta \Delta \texttt{RSV/GDP}_t + \varepsilon_{j,t} \tag{2}$$

The regressand `sterilization_bond` includes both government bonds and central bank securities (Monetary Stabilization Bond). In Korea, the majority of FX reserves are managed by the central bank, but a part of the reserve is under the direct control of the government (the exact size of it is not known). The government conducts a foreign exchange intervention with its own account, and the operation is funded by the issuance of government bonds. Therefore, for this part of the reserve, sterilization is done by government bonds, while the central banks' share of reserves is sterilized by the central bank issued security. Furthermore, the government and central bank bond do not differ significantly except in maturities,[4] because both are regarded as the safest assets in Korea. The issuers are the Korean government and the central bank. Banks easily exchange one for the other during their daily security transactions. Therefore, we count both government bonds and central bank bonds from bank balance sheets in measuring the impact of sterilized reserve accumulation.

Since banks' holdings of government bonds and central bank bonds can increase (or

[4]The government bond is generally issued with maturities over three years, while maximum maturity of the central bank security is two years.

decrease) for many reasons other than reserve accumulation and sterilization, we regress the growth in banks' sterilization bonds holdings on reserve accumulation to obtain the reserve accumulation-induced part of the change in banks' bond holdings. Importantly, we use bank fixed effects in the estimation, and include them in the prediction. Since the regressand is a growth rate relative to assets, bank fixed effects capture each bank's average annual purchases of public bonds relative to their assets over the entire sample period. The reserve stock increased rapidly over the sample period, but the sterilization was done more with some banks than the others. Primary dealer banks and foreign banks eagerly assumed the issued bonds while some other banks rarely trade public bonds (Yun, 2020). The bank fixed effect in the first stage regression capture this bank heterogeneity in their participation in sterilization, and enables us to compare firms with different types of main banks in the second stage.

A total of 24 banks are included in the first stage regression. The sample period is from 2003 to 2017 as the first available bank data are from 2003. In total, there are 217 bank-years. It turns out that the slope coefficient of Equation (3) is positive and significant, as expected. The estimated β is 9.3, with p-value 0.13. It means that, when the reserve is accumulated by 1% of GDP, banks increase holdings of public bonds by 0.1% of their assets in addition to each of their own average annual purchase of the bonds (fixed effects). The overall R-squared is 0.28, with an F-statistic of 3.1.

In the second stage, the predicted value from the first stage regression is used as the firm-level reserve accumulation shock, $\texttt{Firm RSV}_{i,t} (= \hat{y}_{j,t})$. For each firm i at year t, we know the main bank j, and use the predicted increase of the bank j's sterilization bond holdings at year t as the firm specific reserve accumulation shock $\texttt{Firm RSV}_{i,t}$. We now take it as a main regressor, and do an analysis similar to that in the previous section:

$$\texttt{INV}_{i,t} = a_i + a_{j,t} + \rho \texttt{INV}_{i,t-1} + \delta \texttt{CL}_{i,t-1} + \beta \texttt{CL}_{i,t-1} \times \texttt{Firm RSV}_{i,t} + X'\gamma + \epsilon_{i,t} \qquad (3)$$

where $a_{j,t}$ is bank×year fixed effect. It absorbs a common investment rate among firms with the same main bank for each year; therefore, it controls for individual bank-level credit supply shocks. $\texttt{Firm RSV}_{i,t}$ is interacted with the current liability-to-asset ratio $CL_{i,t-1}$. Note that the direct term of $\texttt{Firm RSV}_{i,t}$ is absorbed by the bank×year fixed effects. The coefficient β captures, from the investment rates, the effect of being highly leveraged when the main bank increases public bonds purchases due to reserve accumulation. A negative β means that, within a bank-year, firms with higher current liability-to-asset ratios reduce investment more after their main banks increase holdings of sterilization securities in accordance with reserve accumulation.

Table 3 presents the results. We begin with panel OLS with firm-, bank-, and year fixed effects. Then, we saturate the regressions with bank-year fixed effects to control for unobserved characteristics in each bank and each year dimension as well as for unobserved factors specific to both bank and year. First in Column (1) , which only includes firm and bank fixed effects, the coefficient to the firm-level reserve accumulation shock is negative and statistically significant (=-0.0584). The first stage regression implied that one percentage point increase in reserve accumulation-to-GDP ratio leads to an increase of sterilization bonds-to-asset ratios of banks of 0.1 percentage points. Column (1) implies that the same shock reduces firm investment rate ($\Delta K/K$) by 0.006 (0.6 percentage points). As found in the previous section, credit shortage induced by reserve accumulation may not necessarily affect firms with sound financial conditions. Therefore, Column (2) interacts $\texttt{Firm RSV}_{i,t}$ with the firm's current liability-to-asset ratio, and additionally includes year fixed effects. The negative and significant coefficient on the interaction term means that a high leveraged firm reduces investment more when the main bank increases its holdings of sterilization bonds due to reserve accumulation. Column (3) includes bank-year fixed effects, instead of the separate bank- and year fixed effects ; the interaction term remains significant. The coefficient -0.1443 means that a 75 percentile current liability ratio firm reduces the investment rate by 0.4 (=0.1443× 0.3×0.1×100)

Table 3: *Banks' public bond purchases and firm investment*

	(1)	(2)	(3)	(4)	(5)
Dependent variable : $INV_{i,t}$	Panel OLS	Panel OLS	Panel OLS	Difference GMM	System GMM
$INV_{i,t-1}$	-0.0609***	-0.0590***	-0.0584***	0.0081	0.0085
	(0.010)	(0.011)	(0.011)	(0.009)	(0.009)
Firm $RSV_{i,t}$	-0.0584***	1.1764			
	(0.007)	(1.131)			
Firm $RSV_{i,t} \times CL_{i,t-1}$		-0.1469**	-0.1443**	-0.1278***	-0.1042**
		(0.064)	(0.061)	(0.041)	(0.042)
$CL_{i,t-1}$	0.1964***	0.2504***	0.2477***	0.5811***	0.7631***
	(0.027)	(0.027)	(0.028)	(0.050)	(0.053)
$Leverage_{i,t-1}$	-0.4009***	-0.3686***	-0.3702***	-0.8336***	-1.2330***
	(0.074)	(0.075)	(0.073)	(0.071)	(0.072)
Cash $flow/Assets_{i,t-1}$	0.0927**	0.0926*	0.0935*	-0.1463**	-0.1638***
	(0.042)	(0.047)	(0.045)	(0.058)	(0.058)
Sales $growth_{i,t-1}$	0.0652***	0.0671***	0.0677***	0.0619***	0.0472***
	(0.010)	(0.009)	(0.010)	(0.013)	(0.013)
$Size_{i,t-1}$	-0.2675***	-0.2934***	-0.2939***	-0.9761***	-0.7832***
	(0.019)	(0.024)	(0.024)	(0.031)	(0.027)
Int. paid to $EBITA_{i,t-1}$	-0.0989***	-0.1070***	-0.1061***	-0.0611***	-0.0629***
	(0.020)	(0.021)	(0.019)	(0.020)	(0.020)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Bank×Year Fixed effects	No	No	Yes	Yes	Yes
Bank Fixed Effects	Yes	Yes	–	–	–
Year Fixed Effects	No	Yes	–	–	–
Weak IV test (p-value)				0.00	0.00
Over id test (p-value)				–	–
AR(1)/AR(2)				0.00/0.69	0.00/0.41
# of instruments				234	239
# of firms	8,293	8,293	8,293	7,660	12,049
# of banks	24	24	24	22	23
Observations	36,818	36,818	36,818	24,164	40,574
R-squared	0.322	0.323	0.326		

Notes: This table shows the results with firm level reserves shock identified by a firm's main banks public bond holdings. The dependent variable is the firm level investment rate ($INV_{i,t-1}$). Firm RSV indicates predicted increases in the main bank's holdings of public bonds, obtained from the first stage regression where banks' public bond holding growth rate is regressed on reserve accumulation. $CL_{i,t-1}$ is firm-level current liability to assets ratio. We control for factors that influence firm-level investment that previous studies specified. The sample period is 2003-2017. (One-step) GMM is employed in columns (4) and (5). Bank×year fixed effects are included in columns (3)-(5). Two-way clustered standard errors at firm and year are reported in the parentheses in columns (1)-(3), and those at firm level in columns (4)-(5). *, **, *** means significant at the 10%, 5%, and 1% level, respectively.

percentage points more than a 25 percentile firm after their main bank increases holdings of sterilization securities by 0.1% to their assets (i.e. when the reserve is accumulated by 1% of GDP). This is significant given that the average reserve accumulation is 2% of the GDP over this sample period, with a standard deviation of 3% of the GDP.

Columns (4)-(5) do difference and system GMM estimations considering the lagged regressand in the regression. In both columns, the interaction term remains significant while the coefficient size contracts somewhat. This implies that the previous results are not significantly affected by the Nickell bias. Here, the proliferation of bank-year fixed effects increases the degree of freedom in the estimation, and our models become just identified. Our test statistics, such as weak IV test and AR(1) and AR(2) specification tests, support the validity of the model.

4. Sub-sample Analyses and Robustness

This section presents additional results from an alternative specification by considering various firm-level and bank-level characteristics, and provides sub-sample analyses to understand the findings better.

4.1. Sample of Active Counterparty Banks to Central Bank's Sterilization

An alternative way of utilizing the main bank information is to compare active sterilization security trader banks with the other banks. As explained in the previous section, while certain types of banks (mainly primary dealer banks and foreign banks) actively trade the central bank-issued sterilization securities, other banks rarely do so. If a bank never takes additionally supplied bonds after reserve accumulation, the proposed channel does not work, and the firms who borrow from the bank may not be affected by reserve accumulation. These bank characteristics are captured by the bank fixed effects in the

first round regression of the previous section, but an alternative way to analyze it is to divide the banks into two groups.

As a robustness check, we apply the reserve accumulation shock (reserve accumulation-to-GDP ratio) only to the firms whose main banks hold the central bank sterilization bond on average for more than 3% of their asset over the sample period. For the other firms, the shock is set to zero. By setting the threshold at 3%, we compare 9 active trading banks with the other 16 banks. We test whether this shock could partly explain the variations in firms' investment.

Table 4 presents the results with the alternative firm level reserve variable, $\texttt{Firm RSV1}_{i,t}$, which is the explained new shock. In Column (1), while the coefficient on $\texttt{Firm RSV1}_{i,t}$ is positive, the interaction term with the current liability-to-asset ratio is significantly negative, and its magnitude is about three times larger. Hence, when the bank is an active trader of a sterilization security, most firms (the median of current liability ratio is 0.41) reduce investment after reserve accumulation. Column (2) includes bank-year fixed effects, and the interaction term is still significant and negative. $\texttt{Firm RSV1}_{i,t}$ is omitted due to collinearity to the proliferation of bank-year fixed effects. Column (3) employs system GMM estimation, and column (4) adds bank-year fixed effects. The results are similar to those in Column (1) and (2). Again, Table 4 shows that our main results stay the same, and support the central bank crowding-out of private investments.

4.2. Listed firms vs. Non-listed firms

Next, we compare listed firms with non-listed firms. Large firms, in general, have more routes to fund their investment and rely less on banks. Specifically, listed firms have access to the stock market and can fund their investment by offering equity to investors. The listed firms also tend to be large in size and may have other funding sources. Therefore, we posit that listed firms would be affected less by the reserve accumulation related

Table 4: *Reserve shocks only to the firms whose main banks trade sterilization bonds intensely*

	(1)	(2)	(3)	(4)
Dependent variable : $INV_{i,t}$	Panel OLS	Panel OLS	System GMM	System GMM
$INV_{i,t-1}$	-0.0558***	-0.0547***	0.0639***	0.2260*
	(0.007)	(0.007)	(0.009)	(0.124)
Firm $RSV1_{i,t}$	0.9857***	–	1.1573***	–
	(0.362)		(0.333)	
Firm $RSV1_{i,t} \times CL_{i,t-1}$	-2.7141***	-2.6867***	-3.0807***	-3.4659***
	(0.865)	(0.870)	(0.793)	(0.909)
$CL_{i,t-1}$	0.1921***	0.1908***	0.2346***	0.2937***
	(0.028)	(0.028)	(0.016)	(0.048)
$Leverage_{i,t-1}$	-0.3745***	-0.3767***	-0.2500***	-0.3160***
	(0.034)	(0.034)	(0.016)	(0.053)
Cash flow/$Assets_{i,t-1}$	0.0850*	0.0845*	0.1419***	0.0819
	(0.043)	(0.044)	(0.039)	(0.063)
Sales $growth_{i,t-1}$	0.0693***	0.0698***	0.0525***	0.0315
	(0.011)	(0.011)	(0.010)	(0.020)
$Size_{i,t-1}$	-0.2783***	-0.2790***	-0.0495***	-0.0527***
	(0.012)	(0.012)	(0.003)	(0.004)
Int. paid to $EBITA_{i,t-1}$	-0.1086***	-0.1070***	-0.0937***	-0.0737***
	(0.015)	(0.015)	(0.011)	(0.019)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Bank×Year Fixed Effects	No	Yes	No	Yes
Bank Fixed Effects	Yes	–	Yes	–
Year Fixed Effects	Yes	–	Yes	–
Weak IV test (p-value)			0.00	0.00
Hansen's over id (p-value)			0.213	–
AR(1)/AR(2)			0.00/0.25	0.00/0.21
# of instruments			61	288
# of firms			12,728	12,728
# of banks	25	25	25	25
Observations	41,068	41,069	44,889	44,889
R-squared	0.319	0.323		

Notes: This table shows the results with firm-level reserve shock identified by the firm's main bank's public bond holdings. The dependent variable is the firm investment rate ($INV_{i,t-1}$). Firm RSV1 is the reserve accumulation to GDP ratio, but it is given to only those firms whose bank holds central bank security for more than 3 percent of its assets on average over the sample period. For the other firms, Firm RSV1 is zero. $CL_{i,t-1}$ is firm i's current liability to assets ratio. We control for factors that influence firm investment that previous studies specified. The sample period is 2003-2017. Two step GMM estimators are reported in columns (3) and (4). Bank×year fixed effects are included in columns (2) and (4). Clustered standard errors at firm and year are reported in the parentheses in columns (1) and (2) and those at firm level are in columns (3) and (4). *, **, *** means significant at the 10%, 5%, and 1% level, respectively.

shortages in bank credit supply.

Tong and Wei (2019) argue that reserve accumulation may induce firms to have more leverage, since they may be less concerned about the possibility of the balance of payment crises or exchange rate volatility after reserve accumulation. If reserve accumulation leads firms to increase their leverage, it may imply that reserve accumulation does not worsen firms' funding conditions. As the analysis in Tong and Wei (2019) is done on listed firms only,[5] we find it worth separating our sample into two groups (listed and non-listed firms) to test the robustness of our results.

Table 5 provides results from the listed and non-listed firm sub-samples. Columns (1)-(2) are on listed firms, and Columns (3)-(4) are on non-listed firms. The interaction terms are negative and significant in the non-listed firm sample, but not in the listed firm sample. We find that our proposed effect is mostly coming from non-listed firms, rather than from listed firms. The muted effect of reserve accumulation on listed firms' investment is consistent with Tong and Wei (2019).

4.3. Exporters vs. Non-exporters

When domestic assets are imperfect substitutes for foreign assets due to frictions in the international capital market, or due to capital controls, central bank intervention can affect the exchange rate (e.g., Choi and Taylor, 2017). Reserve accumulation would then depreciate local currency which, in turn, would benefit the exporters. This effect might offset the negative impact of reserve accumulation for exporters. We therefore compare exporters with non-exporters. In Table 6, we separate exporting firms from the rest in the sample to see whether the reserve-induced bank credit shock affect exporters differently. We find that the negative impact of reserve accumulation on investment comes mostly from non-exporters.

[5]Their sample includes 6,610 non-financial firms from 23 emerging market economies including Korea for the period 2000-2006.

Table 5: *Listed vs. non-listed firms*

	(1)	(2)	(3)	(4)
	Listed firms		Non-listed firms	
Dependent variable : $INV_{i,t}$	Panel OLS	System GMM	Panel OLS	System GMM
$INV_{i,t-1}$	-0.0602	0.0580	-0.0636***	0.0083
	(0.045)	(0.047)	(0.013)	(0.009)
Firm $RSV_{i,t} \times CL_{i,t-1}$	-0.0091	-0.0734	-0.1439**	-0.1231***
	(0.119)	(0.242)	(0.061)	(0.044)
$CL_{i,t-1}$	0.1855	0.4510*	0.2446***	0.7948***
	(0.139)	(0.249)	(0.034)	(0.055)
$Leverage_{i,t-1}$	-0.4295**	-1.2371***	-0.3516***	-1.2022***
	(0.166)	(0.380)	(0.074)	(0.076)
Cash flow/$Assets_{i,t-1}$	0.1779	0.0255	0.0922*	-0.1768***
	(0.181)	(0.207)	(0.050)	(0.061)
Sales $growth_{i,t-1}$	0.2073***	0.0618	0.0519***	0.0473***
	(0.047)	(0.061)	(0.016)	(0.014)
$Size_{i,t-1}$	-0.2639***	-0.5641***	-0.2975***	-0.8348***
	(0.050)	(0.135)	(0.021)	(0.029)
Int. paid to $EBITA_{i,t-1}$	-0.1117	-0.1397	-0.1053***	-0.0597***
	(0.075)	(0.098)	(0.025)	(0.021)
Bank-Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Weak IV test (p-value)		0.00		0.00
Hansen's over id (p-value)		–		–
AR(1)/AR(2)		0.00/ 0.013		0.00/ 0.84
# of instruments		201		239
# of firms	638	882	7,708	11,353
# of banks	19	19	22	22
Observations	3,160	3,404	33,525	37,170
R-squared	0.368		0.332	

Notes: This table shows the results for sub-sample analysis of listed firms and non-listed firms. The dependent variable is the firm level investment rate ($INV_{i,t-1}$). Firm RSV indicates predicted increases in the main bank's holdings of public bonds. It is obtained from the first stage regression where banks' public bond holding growth rate is regressed on reserve accumulation. $CL_{i,t-1}$ is firm level current liability to assets ratio. We control for factors that influence firm level investment that previous studies specified. The sample period is 2003-2017. Bank×year fixed effects are included in all columns. Two step GMM estimators are reported in columns (2) and (4). Clustered standard errors at firm and year are reported in the parentheses in columns (1) and (3) and those at firm level are in columns (2) and (4). *, **, *** means significant at the 10%, 5%, and 1% level, respectively.

Table 6: *Exporters vs. non-exporters*

	(1)	(2)	(3)	(4)
	Non-Exporters		Exporters	
Dependent variable : $INV_{i,t}$	Panel OLS	System GMM	Panel OLS	System GMM
$INV_{i,t-1}$	-0.0634***	0.0165*	-0.0367	0.0044
	(0.012)	(0.010)	(0.030)	(0.022)
Firm $RSV_{i,t} \times CL_{i,t-1}$	-0.1427**	-0.1324***	-0.1617	0.0131
	(0.060)	(0.048)	(0.162)	(0.104)
$CL_{i,t-1}$	0.2257***	0.7232***	0.3677**	1.0824***
	(0.036)	(0.057)	(0.123)	(0.152)
$Leverage_{i,t-1}$	-0.3362***	-1.1555***	-0.5114**	-1.6470***
	(0.065)	(0.081)	(0.200)	(0.173)
Cash flow/$Assets_{i,t-1}$	0.0694	-0.2149***	0.1900	0.0174
	(0.060)	(0.067)	(0.109)	(0.120)
Sales $growth_{i,t-1}$	0.0598***	0.0530***	0.0934***	0.0203
	(0.016)	(0.015)	(0.030)	(0.034)
$Size_{i,t-1}$	-0.3086***	-0.8211***	-0.2686***	-0.7390***
	(0.026)	(0.032)	(0.045)	(0.055)
Int. paid to $EBITA_{i,t-1}$	-0.0954***	-0.0608***	-0.1503**	-0.0492
	(0.018)	(0.022)	(0.056)	(0.059)
Bank-Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Weak IV test (p-value)		0.00		0.00
Hansen's over id (p-value)		–		–
AR(1)/AR(2)		0.00/ 0.89		0.00/ 0.03
# of instruments		239		219
# of firms	6,839	10,170	1,454	1,879
# of banks	22	22	20	20
Observations	29,263	32,594	7,555	7,980
R-squared	0.336		0.310	

Notes: This table shows the results for sub-sample analysis of exporting firms and non-exporting firms. Dependent variable is the firm level investment rate ($INV_{i,t-1}$). Firm RSV indicates predicted increases in the main bank's holdings of public bonds. It is obtained from the first stage regression where banks' public bond holding growth rate is regressed on reserve accumulation. $CL_{i,t-1}$ is firm level current liability to assets ratio. We control for factors that influence firm level investment that previous studies specified. The sample period is 2003-2017. Bank×year fixed effects are included in all columns. Two step GMM estimators are reported in columns (2) and (4). Clustered standard errors at firm and year are reported in the parentheses in columns (1) and (3) and those at firm level are in columns (2) and (4). *, **, *** means significant at the 10%, 5%, and 1% level, respectively.

5. Conclusion

Reserve accumulation is a popular policy tool for open economies. Previous studies have found that it can boost growth by promoting export sectors and knowledge spillover, and work against undesired exchange rate appreciation. It can also prevent immense disruption by sudden leaves of foreign capital. Reserve management is likely be the first policy response for a country experiencing severe capital outflows. However, the cost considerations of the reserve is relatively less investigated.

While the literature has long been discussing fiscal costs (i.e., carrying cost) associated with reserve accumulation, studies are scarce on other possible opportunity costs. Costs in investment are apparent from the national accounting identity, but have not been examined from micro-level evidence yet, due to identification difficulties. This paper contributes to the literature by providing firm-level evidence of reserve accumulation negatively affecting investment via financial intermediaries. The effect is identified by linking each firm with its main bank, and tracing firm investment after its main bank increases holdings of sterilization securities in relation to reserve accumulation. The identification is further strengthened by a differences-in-differences scheme which compares firms with different leverage, and also by bank-time fixed effects which controls for fluctuations in individual bank level credit supply.

We find that investment is negatively correlated with reserve accumulation at the firm level. We verify causation by exploiting various dimensions of micro data. The analysis shows that firms with high levels of existing short-term debts reduce investment more compared to less indebted firms. The result implies that leveraged firms find it more difficult to fund their investment when reserve accumulation is intense. This can happen because central banks' sterilization influences commercial banks' ability to generate loans. We confirm this from analysis combining the firm data with bank-level data, and show that leveraged firms reduce investment more when their banks increase sterilization

security holdings due to reserve accumulation. We further find that the effect is more significant to some groups of firms than to others. Exporters and listed firms tend to be less affected.

The findings in this paper have important policy implications. International reserves are useful from many aspects, but does not represent a free lunch. We show that reserves can negatively influence investment. Previous studies that find negative effects of reserve accumulation on bank lending emphasize the macroprudential effects of reserve policy (Hofmann *et al.*, 2019; BIS, 2019; Yun, 2020). Given that reserves are usually accumulated during times of massive capital inflows, these studies document that reserves reducing bank loans and firm leverage can be desirable outcomes. What we find in this paper complete the picture by showing that the effect of reserve accumulation can extend to corporate investment. Whether the outcome is desirable or not should be judged carefully therefore.

Studies focusing on firm heterogeneity often find that the small firm responds sensitively to changes in financial conditions and makes real impact. For instance, Forbes (2007) finds that the burden of capital control falls primarily to small firms that cannot switch to other sources of funding. Likewise, Kashyap and Stein (2000) find that the monetary policy effect is realized mainly through small banks with less liquid balance sheets. In our investigation on firm heterogeneity, we also find that the negative effects of reserve accumulation on investment are more pronounced for highly indebted, non-exporting, non-listed firms. From the policy perspective, small firms need to receive more consideration regarding both the intended policy effects and unintended side effects.

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