Long-term interest rates and bank loan supply: Evidence from firm-bank loan-level data

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* The views expressed are ours and do not necessarily reflect those of the Bank of Japan or any of the institutions with which we are affiliated.

Research background

- Empirical evidence on unconventional monetary policies (MP):
  - Unconventional MP lowered long-term interest rates (Fukunaga et al. 2015, Gagnon et al. 2011, Krishnamurthy and Vissing-Jorgensen 2011).
  - Institutional investors rebalanced their portfolios towards riskier assets (Carpenter et al. 2015, Joyce et al. 2014, Foley-Fisher et al. 2016).

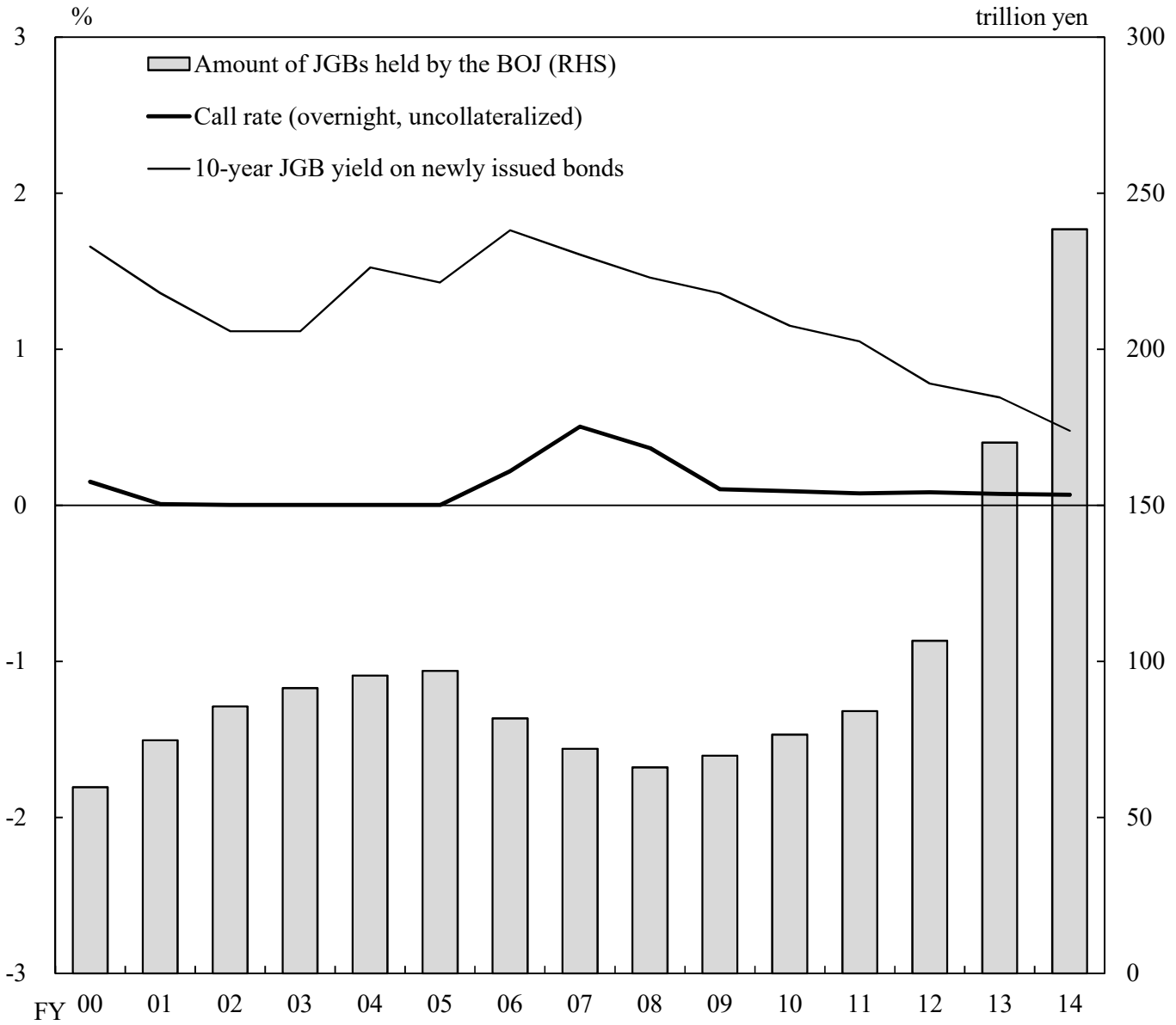
Research background

- Mixed evidence on the impact of unconventional MP on **bank loan supply**
  - Unconventional MP increased bank loan supply (Bottero et al. 2022, Rodnyansky and Darmouni 2017).
  - Unconventional MP (esp. negative interest rates) reduced bank loan supply (Brunnermeier and Koby 2018, Heider et al. 2019).

What we do

- We examine whether the decline in **long-term interest rates** has stimulated **bank loan supply**.
  - We examine three transmission channels of a change in long-term interest rates simultaneously.
    - (i) **portfolio balance channel**
    - (ii) **bank balance sheet (BS) channel**
    - (iii) **risk-taking channel**
  - Previous studies have examined these channels independently.
  - Data: Firm-bank panel data in Japan during 2002–2014

MP and long-term interest rates



What we find

- **Portfolio balance channel**: Unanticipated reductions in long-term interest rates increased bank loan supply.
  - The effect is stronger for banks with higher expected returns on loans.
- **Bank BS channel:** Banks that enjoyed capital gains on their bond holdings increased bank loan supply. However, we find an insignificant result when firm-year fixed effects are controlled for.
- **Risk-taking channel:** The positive effect of capital gains on bonds was stronger in the case of loans to smaller, more leveraged, and less creditworthy firms.
- The transmission channels of MP are heterogeneous among banks and firms.

Outline

- Developments in monetary policy and bank portfolios in Japan
- Theoretical model (intuition)
- Data, empirical strategy
- Results
- Conclusion

THEORETICAL MODEL

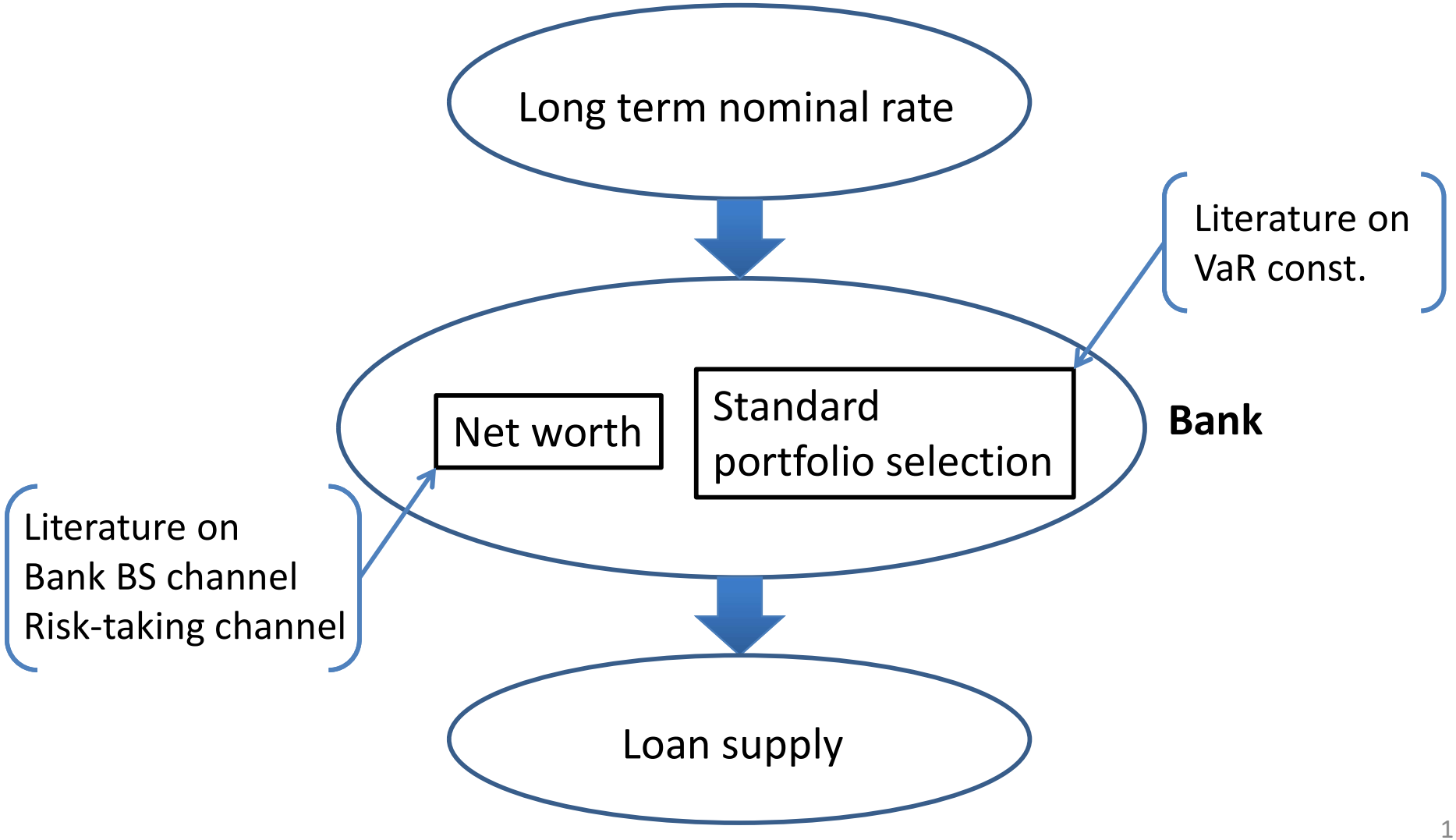
Overview

- A simple **mean-variance model** of bank portfolio selection, subject to **the value-at-risk (VaR) constraint** (Adrian and Shin 2011)
  - We consider a bank that invests in loans and government bonds, taking the prices of those assets as given.
  - VaR constraint: Bank should hold sufficient net worth to absorb losses from loans and bonds under the stress event.

Overview

- Three transmission channels through which a change in the price of bonds (long-term interest rates) affects bank loans supply
  - Portfolio balance channel: net of “substitution effect” and “income effect”
  - Bank BS channel: net worth effect
  - Risk taking channel: larger net worth effect for riskier loans.

Overview


Long term nominal rate
Literature on
VaR const.
Net worth
Standard
portfolio selection
Bank
Literature on
Bank BS channel
Risk-taking channel
Loan supply

Bank's BS and expected profit

- Balance sheet constraint

$$L + B = D + N$$

where L: loan, B: bond, D: deposit, N: net worth

- Expected profit

$$\mathrm{E}[\pi] = \mathrm{E}[r_L L + r_B B - r_D D]$$
$$= \mathrm{E}[(r_L - r_D)L + (r_B - r_D)B - r_D N]$$

where r_i: interest rate of i. r_L and r_B are stochastic variables with mean and standard deviation (μ_L, σ_L) and (μ_B, σ_B). We assume $Corr(r_L, r_B) = 0$.

Bank's portfolio selection

- Bank's optimization problem

$$\text{Max } \mathrm{E}[\pi] - \frac{\gamma}{2}\mathrm{Var}[\pi]$$

- VaR constraint

$$(\mu_L - n\sigma_L - r_D)L + (\mu_B - n\sigma_B - r_D)B + r_D N \geq 0$$

$$\underbrace{\frac{r_D - (\mu_L - n\sigma_L)}{r_D}}_{\text{Loss from loans under the stress event}} L + \underbrace{\frac{r_D - (\mu_B - n\sigma_B)}{r_D}}_{\text{Loss from bonds under the stress event}} B \leq N$$

n: the magnitude of stress (the volatility of bank assets under which the bank is solvent)

Effect of a decrease in μ_B

Expected return of bond ↓

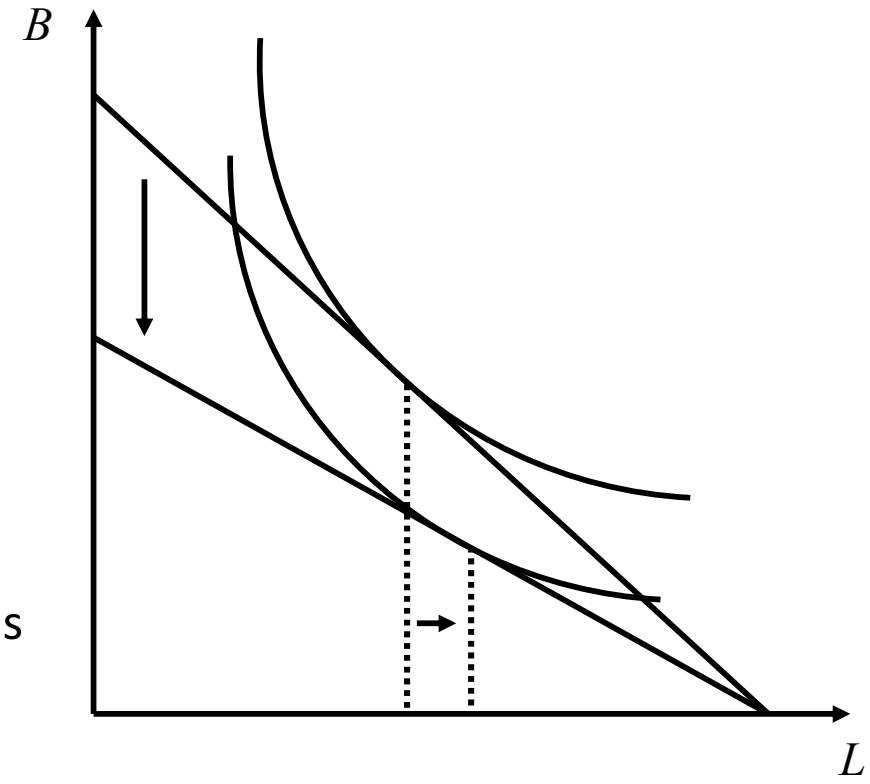
Substitution effect:
L↑, B↓

Income effect:
L↓, B↓

Increase in relative profitability of loans

Increase in loss from bonds under the stress event, which tightens the VaR constraint

【$\frac{\partial L}{\partial \mu_B}$, substitution effect>income effect】



Effect of an increase in N

Decrease in bond interest rates↓
= Increase in the value of banks' bond holdings ↑

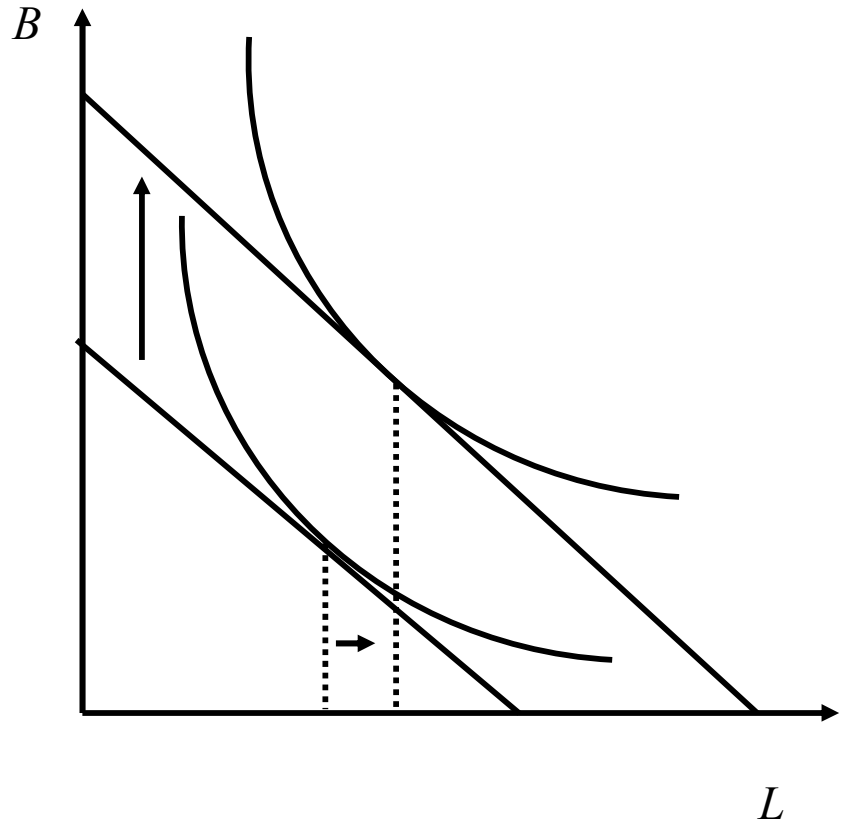
↓

Increase in banks' net worth ↑
(VaR constraint is less binding)

↓

Net worth effect: L↑, B↑

【$\frac{\partial L}{\partial N}$, net worth effect】



Effect of an increase in N

- Introducing 2 types of loans: safe L and risky R
- Risky loans have a higher mean, higher standard deviation, and lower Sharpe ratio (risk premium),

$$\mu_L < \mu_R, \sigma_L < \sigma_R, \frac{\mu_L - r_D}{\sigma_L} > \frac{\mu_R - r_D}{\sigma_R}.$$

- Under the above assumptions, we can show:

$$\frac{\partial [R^{**}/L^{**}]}{\partial N} > 0$$

  - In response to an increase in net worth, the bank increases risky loans more than safe loans.

DATA, EMPIRICAL STRATEGY, AND VARIABLES

Data and sample selection

- Firm-bank matched loan-level data for 2002-2014
  - Unbalanced panel: **379,989** observations
- Firm and loan data: Teikoku Databank (TDB) database
  - Sample selection: Firms for which data on (i) the total loans outstanding, (ii) the amount of loans outstanding from at least two banks, and (iii) the TDB credit score are available

  ➔48,975 firms
- Bank-level data: Nikkei Financial Quest, JBA, annual reports
  - Sample selection: City banks, regional banks, Shinkin banks.

  ➔ 408 banks
- Macroeconomic variables: Nikkei Financial Quest

Identification challenges

- Disentangling the effect on **loan supply** from that on **loan demand**.
  - Our strategy: Using **firm-bank panel data** to control for loan demand using fixed effects (e.g., firm-year FE).
- **Endogeneity** of MP
  - If a change in MP is anticipated, there is a possibility of reverse causality (Khawaja and Mian 2008).
  - Our strategy: Employing changes in long-term **forward** interest rates, which reflect **unanticipated** component of expected returns on bonds
    - Some studies rely on settings where MP is independent of economic conditions (Jiménez et al. 2012, Ioannidou et al. 2015)

Empirical strategy

- Usual OLS regression yields biased estimates of α if a firm-specific loan demand shock is unobservable.

$$\Delta LOANS(i,j) = \alpha_0 + \alpha_1 \Delta BONDRATE + \alpha_2 BK\_CAPGAIN(j) + \alpha_3 F\_DEMAND(i) + \varepsilon(i,j)$$

Portfolio balance channel

Bank BS channel

- If we observe a change in loans to the same firm by another bank j', we can eliminate $F\_DEMAND(i)$ by taking differences of two equations.

$$\Delta LOANS(i,j) - \Delta LOANS(i,j') = \alpha_2\{BK\_CAPGAIN(j) - BK\_CAPGAIN(j')\} + \{\varepsilon(i,j) - \varepsilon(i,j')\}$$

Sample selection: firms that transacts with only one bank are excluded

Empirical specification (1)

- Main estimations

$\beta_1 < 0$ if substitution effect > income effect

$$\Delta LOANS(i,j,t) = \beta_0 + \beta_1 \Delta BONDRATE(t-1) + \beta_2 BK\_CAPGAIN(j,t-1)$$

i: firm, j: bank, t: year

$\beta_2 > 0$ if net worth effect exists

$$+\boldsymbol{\beta_3}\mathbf{CONTROLS} + \mathbf{Fixed\ Effects} + \varepsilon(i,j,t)$$

(i) firm, bank, (ii) firm, year, bank, **(iii) firm-year, bank**

– Specifications (ii) and (iii): we cannot estimate $\Delta BONDRATE$

Empirical specification (2)

- Cross-term estimations

$\theta_1 < 0$ if substitution effect is stronger for banks facing higher loan rates

$$\Delta LOANS(i,j,t) = \theta_0$$
$$+\theta_1 \Delta BONDRATE(t-1) \times BK\_\Delta LOANRATE(j,t-1)$$
$$+\theta_2 BK\_CAPGAIN(j,t-1)$$
$$+\boldsymbol{\theta_3 CONTROLS} + \textbf{Fixed Effects} + \varepsilon(i,j,t)$$

firm-year, bank

– **Interaction terms with bank-specific loan interest rates** show the heterogeneity among banks regarding the portfolio balance channel.

Empirical specification (3)

- Cross-term estimations

$$\Delta LOANS(i,j,t) = \lambda_0$$

$$+\lambda_1 BK\_CAPGAIN(j,t-1) \times FIRM\_RISK(i,t-1)$$

$$+\boldsymbol{\lambda_3 CONTROLS} + \textbf{Fixed Effects} + \varepsilon(i,j,t)$$

$\beta_2 > 0$ if net worth effect is stronger for loans to risky firms

firm-year, bank

– **Interaction terms** with firm-level variables **representing firms' riskiness** (size, leverage, credit score) show whether the effect of increase in bank net worth is stronger for loans to riskier firms (risk-taking channel).

RESULTS

Main results (Table 3)

	(i)	(ii)	(iii)	(iv)
Key independent variables				
ΔBONDRATE	-1.84 *			
	(0.95)			
BK_CAPGAIN	5.11 ***	3.37 *	4.33	4.20
	(1.38)	(2.00)	(2.71)	(2.72)
ΔBONDRATE ×BK_ΔLOANRATE				-4.57 ***
				(1.15)
Macroeconomic controls	YES	–	–	–
Bank characteristics	YES	YES	YES	YES
Firm characteristics	YES	YES	–	–
Fixed effects				
Firm	YES	YES	–	–
Year	–	YES	–	–
Firm-year	–	–	YES	YES
Bank	YES	YES	YES	YES
Observations	379,989	379,989	379,989	379,846
Adjusted R^2	0.04	0.04	0.21	0.21

Main results (Table 3)

	(i)	(ii)	(iii)	(iv)
Key independent variables				
ΔBONDRATE	-1.84 * (0.95)			
BK_LAG_GAP	5.11 ***	3.37 *	4.33	4.20
				-4.57 *** (1.15)
Macroeconomic control	YES	YES	–	–
Bank characteristics	YES	YES	YES	YES
Firm characteristics	YES	YES	–	–
Fixed effects				
Firm	YES	YES	–	–
Year	–	YES	–	–
Firm-year	–	–	YES	YES
Bank	YES	YES	YES	YES
Observations	379,989	379,989	379,989	379,846
Adjusted R^2	0.04	0.04	0.21	0.21

Portfolio balance channel: $\Delta BONDRATE$ is negative and weakly significant.

- Modest but not negligible economic significance: A 100-basis point decrease in the long-term forward rate increases loan growth rate (mean: −5.2%) by 1.8 percentage points.

Main results (Table 3)

	(i)		(ii)		(iii)		(iv)	
Key independent variables								
ΔBONDRATE	-1.84	*						
	(0.95)							
BK_CAPGAIN	5.11	***	3.37	*	4.33		4.20	
	(1.38)		(2.00)		(2.71)		(2.72)	
ΔBONDRATE×BK_ALOANRATE							-4.57	***
							(1.57)	
Macroeconomic controls	YES		–		–		–	
Bank characteristics	YES		YES		YES		YES	
Firm characteristics	YES		YES		–		–	
Fixed effects								
Firm	YES		YES		–		–	
Year	–		YES		–		–	
Firm-year	–		–		YES		YES	
Bank	YES		YES		YES		YES	
Observations	379,989		379,989		379,989		379,846	
Adjusted R^2	0.04		0.04		0.21		0.21	

Larger standard errors suggest heterogeneity among firms and banks

Bank BS channel: $BK\_CAPGAIN$ is significantly positive in column (i), but it is weakly significant in column (ii) and insignificant in column (iii).

Main results (Table 3)

	(i)	(ii)	(iii)	(iv)
Key independent variables				
ΔBONDRATE	-1.84 *			
	(0.95)			
BK_CAPGAIN	5.11 ***	3.37 *	4.33	4.20
	(1.38)	(2.00)	(2.71)	(2.72)
ΔBONDRATE ×BK_ΔLOANRATE				-4.57 ***
				(1.15)
Macroeconomic controls	YES	–	–	–
Bank characteristics	YES	YES	YES	YES
Firm characteristics	YES	YES		
Fixed effects				
Firm	YES	YES	–	–
Year	–	YES	–	–
Firm-year	–	–	YES	YES
Bank	YES	YES	YES	YES
Observations	379,989	379,989	379,989	379,846
Adjusted R^2	0.04	0.04	0.21	0.21

Relative strength of the portfolio balance channel:

$\Delta BONDRATE \times BK\_\Delta LOANRATE$ is significantly negative.

- The substitution effect is larger than the income effect especially for a bank facing a higher loan rate.

Risk-taking channel (Table 4)

		(i)	(ii)	(iii)
Interaction term with *BK_CAPGAIN*		*dum_F_lnTA_small*	*dum_F_CAP_small*	*dum_F_SCORE_low*
Below / above median	Small (low)	15.29 ***	8.83 ***	6.57 *
		(4.97)	(2.79)	(3.62)
	Large (high)	0.54	-2.76	3.64
		(2.87)	(4.57)	(3.36)
Bank characteristics		YES	YES	YES
Fixed effects				
Firm-year		YES	YES	YES
Bank		YES	YES	YES
Observations		379,989	379,989	379,109
Adjusted R^2		0.21	0.21	0.21

Risk-taking channel (Table 4)

	(i)	(ii)	(iii)
Interaction term with *BK_CAPGAIN*	*dum_F_lnTA_small*	*dum_F_CAP_small*	*dum_F_SCORE_low*
Small (low)	15.29 ***	8.83 ***	6.57 *
	(4.97)	(2.79)	(3.62)
Large (high)	0.54	-2.76	3.64
	(2.87)	(4.57)	(3.36)
Bank characteristics	YES	YES	YES
Fixed effects			
Firm-year	YES	YES	YES
Bank	YES	YES	YES
Observations	379,989	379,989	379,109
Adjusted R^2	0.21	0.21	0.21

Below / above median

Risk-taking channel: Significant positive coefficients for firms that are smaller, have a lower capital-asset ratio, and have a lower credit score

- Net worth effect is stronger for loans to riskier firms.

CONCLUSION

Summary

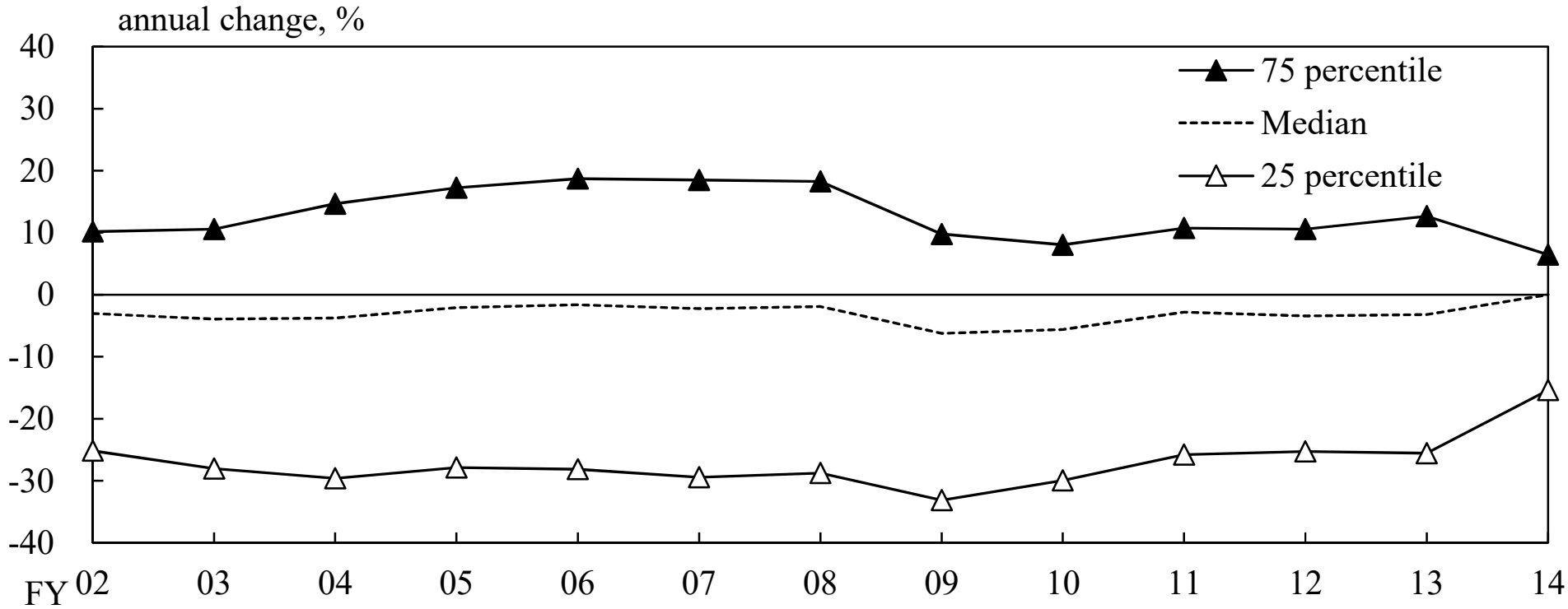
- It is important to take the heterogeneity across banks and borrowing firms into account when examining the transmission channels of MP.
- The portfolio balance channel was stronger for banks with higher expected returns on loans.
- The bank BS channel was stronger in the case of loans to smaller, more leveraged, and less creditworthy firms (risk-taking channel).

END OF PRESENTATION
THANK YOU

SUPPLEMENTARY SLIDES

Variables: $\Delta LOANS$

Log change in firm i's total loans outstanding from bank j



Variables: $\Delta BONDRATE, BK\_CAPGAIN$

- $\boldsymbol{\Delta BONDRATE}$: Difference between the forward interest rates observed in year *t-1* for 10-year bonds starting in year *t* and the forward rate observed in year *t-2* for the same 10-year bond starting in year *t*

$$\Delta BONDRATE = f_{t-1}(t, t+10) - f_{t-2}(t, t+10)$$

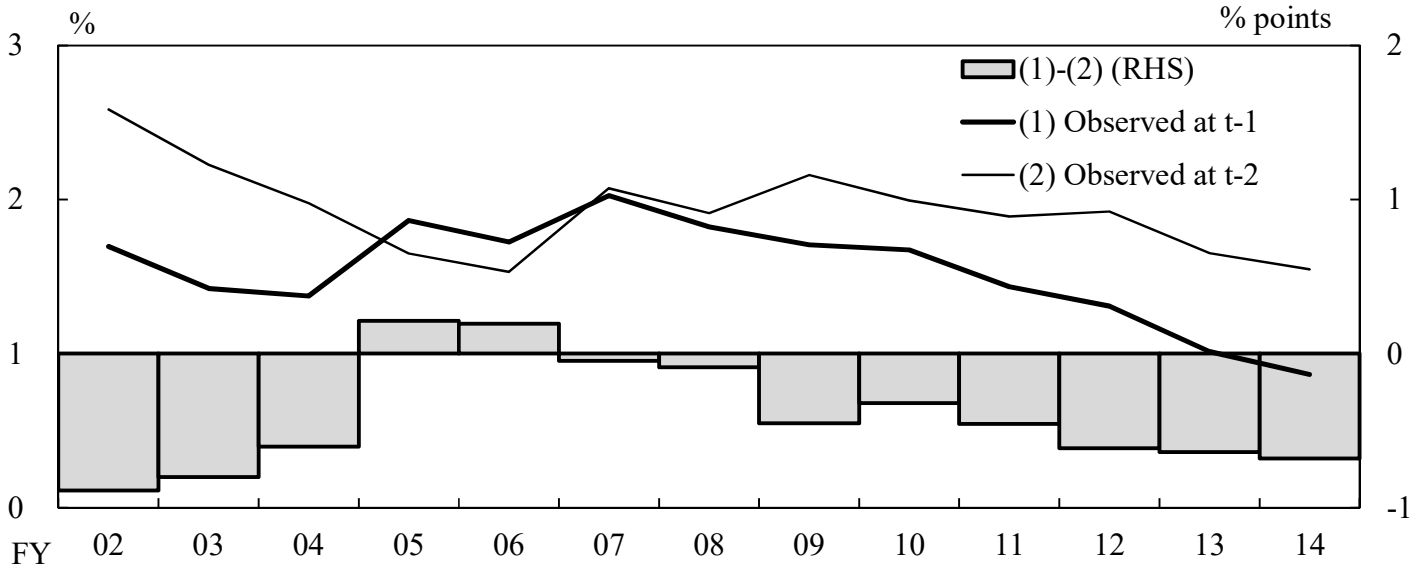
- $\boldsymbol{BK\_CAPGAIN}$: Bank-specific capital gains/losses due to changes in prices of bonds held

$$\frac{-\sum_s \left(\Delta BONDRATE\_SPOT_t(s) \times BK\_BOND_{t-1}(s) \times s \right)}{BK\_TA_{t-1}}$$

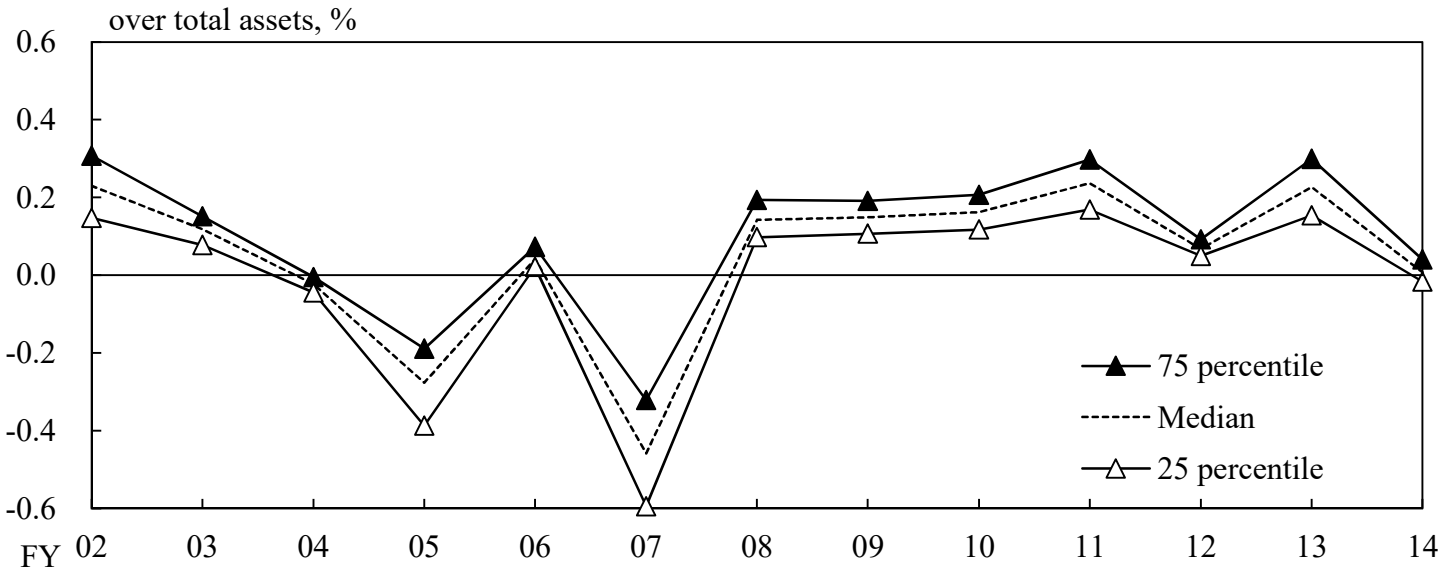
where s: maturity of bonds

Variables: $\Delta BONDRATE, BK\_CAPGAIN$

$\Delta BONDRATE$



$BK\_CAPGAIN$



Other control variables

- Macroeconomic controls: $\Delta LOANRATE$, ΔNPL, ΔGDP, $\Delta TOPIX$
- Bank characteristics: BK_CAP, BK_CAP_SQ, BK_NPL, BK_LIQ, BK_ROA, BK_lnTA
- Bank-firm relationships: BK_MAIN
- Firm characteristics: F_CAP, F_LIQ, F_ROA, $F\_\Delta SALES$, F_lnTA, F_AGE, $F\_lnNBANKS$
- To deal with possible outliers, following variables are winsorized at the upper and lower 0.5 percentiles : $\Delta LOANS$, F_CAP, F_LIQ, F_ROA, $F\_\Delta SALES$