Bank Lending Standards, Uncertainty and Monetary Policy Transmission

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Uncertain times

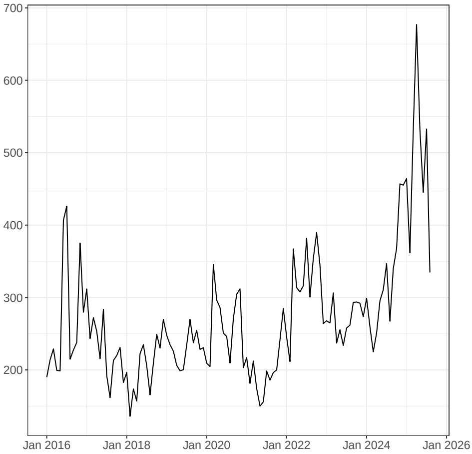


Figure: Economic Policy Uncertainty across large euro area countries (source: Bloom et al), last observation: August 2025

Motivation

- Uncertainty affects bank lending and firm investment decisions
  - Increase in value of waiting [Bernanke, 1983, Rodrik, 1991]
  - Tightening of financial constraints [Christiano et al., 2014]
- As a consequence
  - Firms postpone investment [Bloom, 2009]
  - Banks tighten credit supply [Jasova et al., 2021, Correa et al., 2023, Altavilla et al., 2019b]

Does uncertainty affect monetary policy transmission? and how?

Main Findings

1. Uncertainty affects bank loan pricing behavior
   - Higher uncertainty is associated to a steepening of the bank loan supply curve
2. Tighter bank lending standards impact the transmission of monetary policy
   - Reduced responsiveness of credit and increased responsiveness of lending rates to monetary policy shocks – similar to Ottonello and Winberry [2020]

$\Longrightarrow$ **The strength of monetary policy transmission depends on the degree of uncertainty in the economy**

Outline

1. *Does uncertainty affect transmission?*
   - Motivating evidence using state-dependent panel LP and monetary policy surprises
2. *How?*
   - Model-based mechanism: quantitative macro-banking model
   - Highlight the existence of a channel via bank lending standards
3. *Empirical validation of the mechanism*
   - Estimating loan supply curves using loan-level data from the euro area credit register (AnaCredit)

Literature review

- Impact of uncertainty on firm-level investment [Bloom, 2009, Gulen and Ion, 2016, Kaviani et al., 2020]
- Impact of uncertainty on bank lending: trade uncertainty [Correa et al., 2023], EPU uncertainty [**Behn et al. 2025**] funding uncertainty [Altavilla et al., 2019b, Jasova et al., 2021]
- Effects of uncertainty on monetary policy transmission
  - Focus on financial markets and real variables [Hauzenberger et al., 2021, Aastveit et al., 2017]
  - Focus on firms' real options channel [Lu et al., 2025, Lakdawala and Moreland, 2024]

$\Longrightarrow$ This paper proposes a new mechanism operating through **bank lending standards**

Motivating Empirical Evidence

Does uncertainty affect monetary policy transmission?

We estimate the following state-dependent panel LP for firm i quarter t horizon h:

$$\Delta log(Debt_{it,t+h}) = \beta * \sigma_{it-1} * MP_t + Y_{it-1} * MP_t + FE_{s(i)t} + FE_{c(i)t} + \sum_{l=0}^{L} X_{it-l} + \sum_{l=1}^{L} \Delta log(Debt_{it-l,t-l+1}) + \epsilon_{it},$$

- σ_{it}: firm-level realized return volatility in the baseline ‣ Realized volatility
- MP shocks are target component of the high-frequency movements on GovC days as in Altavilla et al. [2019a]
- controls X_{it}: EBITDA margin, sales qoq growth, total asset qoq growth
- interaction of total assets (Y_{it-1}) and MP, country-quarter and sector-quarter fixed effects
- panel of euro area listed firms since 2000 (source: Eikon) ‣ Descriptives
- $L = 2$, standard errors clustered at firm level

Higher uncertainty dampens monetary policy transmission

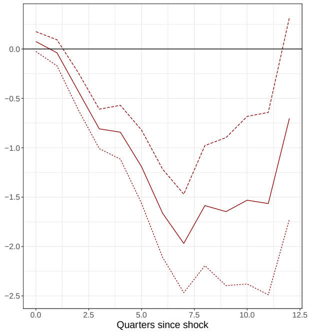


Figure: Effect of MP on lending

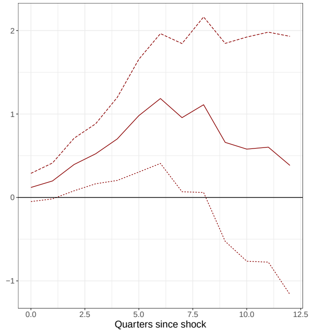


Figure: Interaction of MP and uncertainty (β)

- A 1 sd higher firm-level volatility dampens the effect of a 1 sd MP shock on loan growth by around 1 pp at its peak (20-65% of the estimated direct effect).

Results

Dependent Variable:	$\Delta log(Debt)1Y - ahead$			
	NoFE	Vol30D	Vol90D	Vol180D
Model:	(1)	(2)	(3)	(4)
Variables				
MP	-0.8428***			
	(0.1391)			
MP:L(Uncertainty)		0.7761***	0.7016***	0.6885***
		(0.2383)	(0.2539)	(0.2607)
Fixed-effects				
Sector-time	No	Yes	Yes	Yes
Country-time	No	Yes	Yes	Yes
Fit statistics				
Observations	88,854	79,523	79,900	80,134
R^2	0.06934	0.14342	0.14390	0.14379
Within R^2		0.06690	0.06737	0.06725

*Notes: Standard errors are clustered at the firm level. Monetary policy shocks are target components of high-frequency interest rate movements as in Altavilla et al. [2019b]. Codes: ***: 0.01, **: 0.05, *: 0.1.*

Robustness

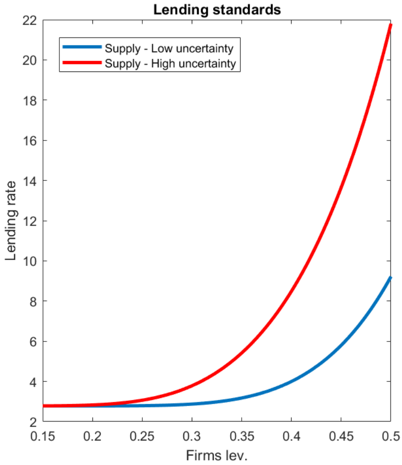
- Different monetary policy shocks ▸ Alternative MP shocks
- Different measurements of uncertainty ▸ Earnings per share disagreement
- Dampens transmission to corporate investment ▸ Investment - chart ▸ Investment - table

Proposed Mechanism

The model

- We rationalize the empirical evidence through the lens of a quantitative macro-banking model
- The role played by uncertainty in this context:
  - The returns of borrowers are subject to an unanticipated idiosyncratic shock that determines the success of the business plan
  - Exogenous changes to the variance of this idiosyncratic shock are used to capture different levels of uncertainty
  - Loan supply schedule steepens upon higher uncertainty due to increased borrower risk
  - Reduced responsiveness of credit/investment and increased responsiveness of lending rates to MP shocks

Uncertainty and Bank Lending Standards



- Higher uncertainty increases borrowers default risk
- Loan supply schedule steepens: banks require a higher lending rate for a given firm leverage

Empirical Validation

Evidence of supply curve steepening using micro data

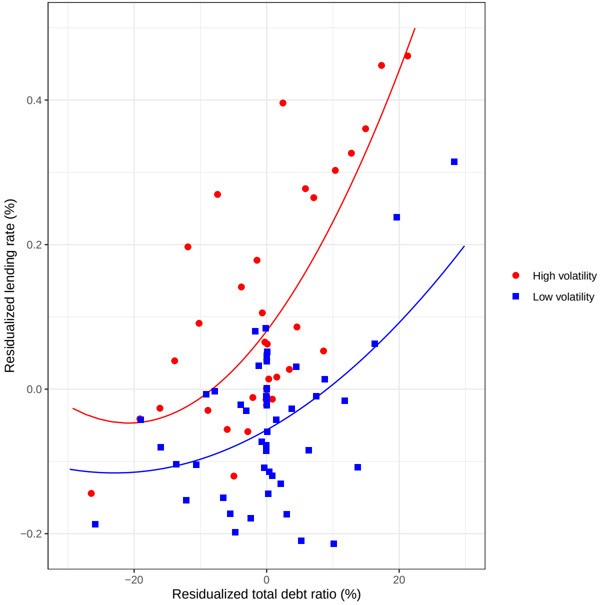
Idea: holding supply constant per segment, find the link between leverage ratio and lending rate depending on firm volatility.

We estimate the following equation for firm i bank j loan l time t:

$$
\begin{aligned}
R_{ijlt} = & \beta \times TotalDebtRatio_{it} \times \mathbb{1}\{VolHigh_{it}\} + log(Loan_{ijlt}) + Mat_{lt} + \\
& \mathbb{1}\{Scrd_l\} + \mathbb{1}\{Instr_{lt}\} + \mathbb{1}\{TypRate_{lt}\} + X_{it} + FE_{jt} + FE_{s(i)t} + \epsilon_{ijlt}
\end{aligned}
$$

- $VolHigh_{it}$ is a dummy taking value 1 when realized return volatility above median/ volatility levels
- Supply assumed fixed by bank-time, sector-time, type of loan
- Euro area credit registry AnaCredit: banks loans ($\geq$ €25,000) to all EA firms merged with Eikon to measure uncertainty

Loan supply curve steepens at higher volatility levels



Results

Dependent Variable:	Interest rate			
	Vol90 - dummy	Vol90	Vol180 - dummy	Vol180
Model:	(1)	(2)	(3)	(4)
Variables				
TotalDebtr	0.5051***	0.3367*	0.3023***	0.1300
	(0.0910)	(0.1857)	(0.0964)	(0.2031)
VolHigh	0.0850		-0.0500	
	(0.0727)		(0.0766)	
Vol		0.1342***		0.1612***
		(0.0452)		(0.0470)
TotalDebtr × VolHigh	0.6961***		1.168***	
	(0.1899)		(0.1949)	
TotalDebtr × Vol		0.1770*		0.2515***
		(0.0943)		(0.0966)
Fixed-effects				
Creditor-time	Yes	Yes	Yes	Yes
Rate type-time	Yes	Yes	Yes	Yes
Sector-time	Yes	Yes	Yes	Yes
Instrument type-time	Yes	Yes	Yes	Yes
Fit statistics				
Observations	202,642	202,642	202,731	202,731
R^2	0.66268	0.66288	0.66316	0.66352
Within R^2	0.03590	0.03647	0.03745	0.03847

*Notes: Standard errors are clustered at the borrower level. Volatility is expressed in standard deviation of the 90-days or 180-days realized standard deviation of returns. A debt ratio of 1 corresponds to a ratio of total debt to total assets of 1. The dependent variable is expressed in percent. Dummies correspond to volatilities in above the pooled median. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1.*

▸ Incl. non-listed firms

The steepening is stronger for banks with weaker balance sheets

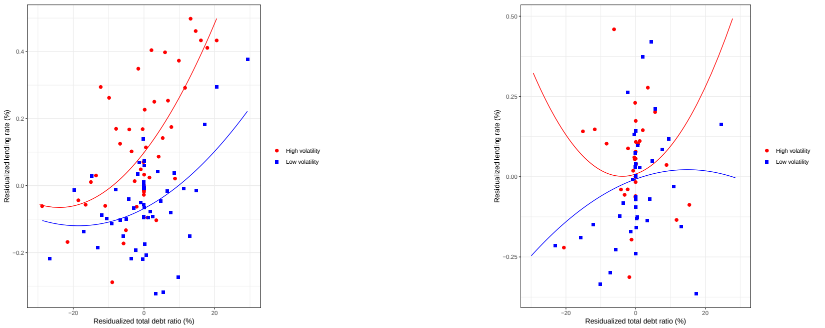


Figure: Estimated loan supply curves for different levels of firm realized volatility for low CET1 ratio banks (LHS) vs high CET1 ratio banks (RHS) ▸ NPL

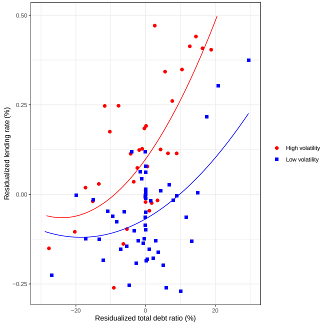
Results - loan supply curve depending on CET1 ratio

Dependent Variable:		Interest rate	
	Baseline	High CET1r	Low CET1r
Model:	(1)	(2)	(3)
Variables			
TotalDebtr	0.3023***	0.2504**	0.3126**
	(0.0964)	(0.1251)	(0.1452)
VolHigh	-0.0500	-0.0010	-0.0771
	(0.0766)	(0.0832)	(0.1297)
TotalDebtr × VolHigh	1.168***	1.039***	1.423***
	(0.1949)	(0.2113)	(0.3379)
Fixed-effects			
Creditor-time	Yes	Yes	Yes
Rate type-time	Yes	Yes	Yes
Instrument type-time	Yes	Yes	Yes
Sector-time	Yes	Yes	Yes
Fit statistics			
Observations	202,731	101,336	87,813
R^2	0.66316	0.73935	0.58527
Within R^2	0.03745	0.02399	0.05940

*Notes: Standard errors are clustered at the borrower level. Codes: ***: 0.01, **: 0.05, *: 0.1.*

▸ NPL

The steepening is stronger for banks with weaker balance sheets



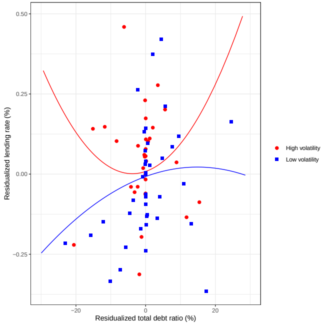


Figure: Estimated loan supply curves for different levels of firm realized volatility for low NPL ratio banks (LHS) vs high NPL ratio banks (RHS)

CET1

Results - loan supply curve depending on NPL ratio

Dependent Variable:		Interest rate	
	Baseline	Low NPLr	High NPLr
Model:	(1)	(2)	(3)
Variables			
TotalDebtr	0.3023***	0.4523***	0.3274***
	(0.0964)	(0.1503)	(0.1243)
VolHigh	-0.0500	0.0861	-0.0418
	(0.0766)	(0.0969)	(0.0997)
TotalDebtr × VolHigh	1.168***	0.5343**	1.277***
	(0.1949)	(0.2519)	(0.2526)
Fixed-effects			
Creditor-time	Yes	Yes	Yes
Rate type-time	Yes	Yes	Yes
Instrument type-time	Yes	Yes	Yes
Sector-time	Yes	Yes	Yes
Fit statistics			
Observations	202,731	62,574	125,113
R^2	0.66316	0.66615	0.65676
Within R^2	0.03745	0.01548	0.05391

*Notes: Standard errors are clustered at the borrower level. Codes: ***: 0.01, **: 0.05, *: 0.1.*

CET1 ratio

Conclusions

This paper studies how uncertainty affects the transmission of monetary policy

- We show that when uncertainty is high banks tighten their lending standards
- Hence, high uncertainty:
  - Reduce the responsiveness of credit...
  - ... and increase the responsiveness of lending rates to monetary policy shocks
- Resulting in an overall more muted impact of monetary policy shocks on investment!

Annex

Additional tables and charts

Firm-level uncertainty (realized volatility) over time

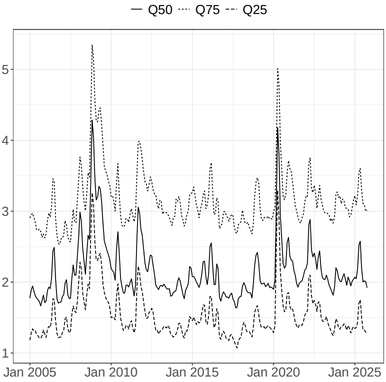


Figure: Distribution of firm-level 90-days realized stock return volatility over time (source: Eikon)

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Descriptive statistics

Variable	n	Min	$\widetilde{x}$	Max	IQR	#NA
Realized volatility (30D) (pp)	112862	0.1	2.1	7.1	1.4	19572
Realized volatility (90D) (pp)	113366	0.5	2.2	6.9	1.5	19068
Realized volatility (180D) (pp)	113683	0.6	2.2	6.8	1.5	18751
Implied volatility (30D) (index)	16577	13.2	29.1	99.1	16.4	115857
Total debt (bn)	124472	0.0	0.1	899.2	0.5	7962
Fixed assets (bn)	132434	0.0	0.0	940.9	0.3	0
Sales qoq growth (%)	115635	-56.3	1.2	123.8	5.2	16799
EBITDA margin (%)	117043	-4270.9	10.9	643.3	14.7	15391
Total assets (bn)	132361	0.0	0.3	1590.3	1.6	73
Assets growth (%)	127714	-45.7	0.7	333.6	5.8	4720

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Alternative monetary policy shocks

Dependent Variable:	$\Delta log(Debt) 1Y - ahead$			
	NoFE	Vol30D	Vol90D	Vol180D
Model:	(1)	(2)	(3)	(4)
Variables				
MP	-1.139***			
	(0.2663)			
MP:L(Uncertainty)		0.9761*	1.065**	0.7784
		(0.5000)	(0.5012)	(0.5113)
Fixed-effects				
Sector-time		Yes	Yes	Yes
Country-time		Yes	Yes	Yes
Fit statistics				
Observations	89,156	79,796	80,173	80,407
R^2	0.06969	0.14421	0.14472	0.14459
Within R^2		0.06719	0.06770	0.06755

*Notes: Standard errors are clustered at the firm level. Monetary policy shocks with the poor man's sign restriction as proposed in Jarociński and Karadi [2020]. Codes: ***: 0.01, **: 0.05, *: 0.1.*

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Effect of forecaster disagreement on MP transmission

Dependent Variable:	$\Delta log(Debt)6Q - ahead$		
	EndY1	EndY2	EndY3
Model:	(1)	(2)	(3)
Variables			
MP:L($\sigma(EPS)$)	3.844^{*}	4.924^{*}	4.602^{**}
	(2.228)	(2.525)	(2.238)
Fixed-effects			
Sector-time	Yes	Yes	Yes
Country-time	Yes	Yes	Yes
Fit statistics			
Observations	36,397	36,018	31,039
R^2	0.17058	0.17092	0.17985
Within R^2	0.06002	0.06004	0.05940

*Notes: Standard errors are clustered at the firm level. Monetary policy shocks are target components of high-frequency interest rate movements as in Altavilla et al. [2019b]. Delta log total debt between t-1 and t+6. $\sigma(EPS)$ is the normalized standard deviation of year-end earning per share forecasts across forecasters. Codes: ***: 0.01, **: 0.05, *: 0.1.*

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Higher uncertainty dampens monetary policy transmission to firm investment

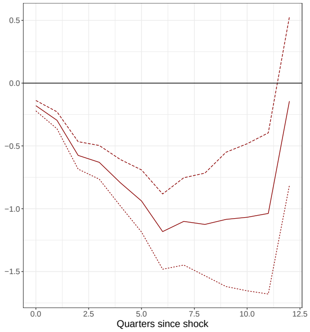

Figure: Effect of MP on investment

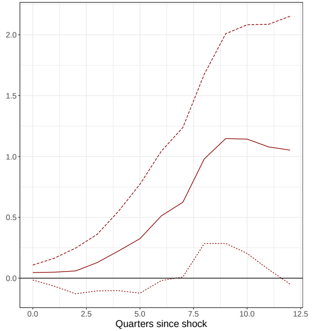

Figure: Interaction of MP and uncertainty (β)

- A 1 sd higher firm-level volatility dampens the effect of a 1 sd MP shock on investment by around 1 pp, wiping out entirely the expected effects of MP on investment Back

Impact on investment

Dependent Variable:		$\Delta log(Invt)2Y - ahead$		
	NoFe	Vol30D	Vol90D	Vol180D
Model:	(1)	(2)	(3)	(4)
Variables				
MP	-1.125***			
	(0.2084)			
MP:L(Uncertainty)		0.8708**	0.9802***	0.9116**
		(0.3533)	(0.3549)	(0.3699)
Fixed-effects				
Sector-time		Yes	Yes	Yes
Country-time		Yes	Yes	Yes
Fit statistics				
Observations	84,352	75,336	75,657	75,846
R^2	0.07767	0.19911	0.19839	0.19800
Within R^2		0.07241	0.07232	0.07228

*Notes: Standard errors are clustered at the firm level. Monetary policy shocks are target components of high-frequency interest rate movements as in Altavilla et al. [2019b]. Codes: ***: 0.01, **: 0.05, *: 0.1.*

▸ Back

Loan supply curves - including non-listed firms

Dependent Variable:	Interest rate			
	90D, dummy	180D, dummy	90D, level	180D, level
Model:	(1)	(2)	(3)	(4)
Variables				
TotalDebtr	0.3656***	0.3775***	0.2615***	0.2412***
	(0.0327)	(0.0349)	(0.0704)	(0.0827)
VolHigh	0.0084	0.0296*		
	(0.0141)	(0.0158)		
Vol			0.0340***	0.0373***
			(0.0107)	(0.0108)
TotalDebtr × VolHigh	0.0689**	0.0460		
	(0.0274)	(0.0315)		
TotalDebtr × Vol			0.0328**	0.0334**
			(0.0131)	(0.0144)
Fixed-effects				
Creditor-time	Yes	Yes	Yes	Yes
Rate type-time	Yes	Yes	Yes	Yes
Sector-time	Yes	Yes	Yes	Yes
Instrument type-time	Yes	Yes	Yes	Yes
Fit statistics				
Observations	4,258,892	4,259,070	4,258,892	4,259,070
R^2	0.67181	0.67181	0.67183	0.67183
Within R^2	0.05028	0.05029	0.05034	0.05037

*Notes: Standard errors are clustered at the borrower level. Volatility is expressed in standard deviation of the 90-days or 180-days realized standard deviation of returns. A debt ratio of 1 corresponds to a ratio of total debt to total assets of 1. The dependent variable is expressed in percent. Dummies correspond to volatilities in above the pooled median. For non-listed firms, average volatility by sector-country is used, if at least 5 firms in the sector-country. Otherwise sector volatility. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1.*

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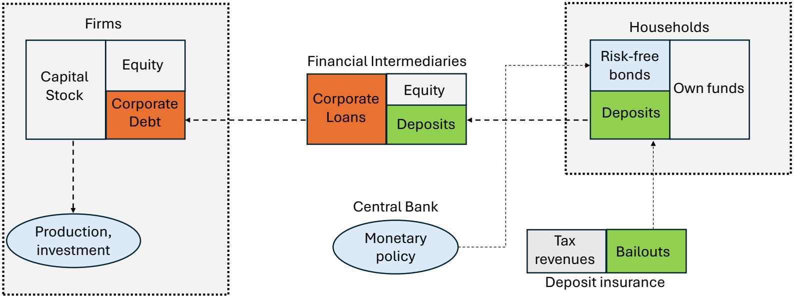
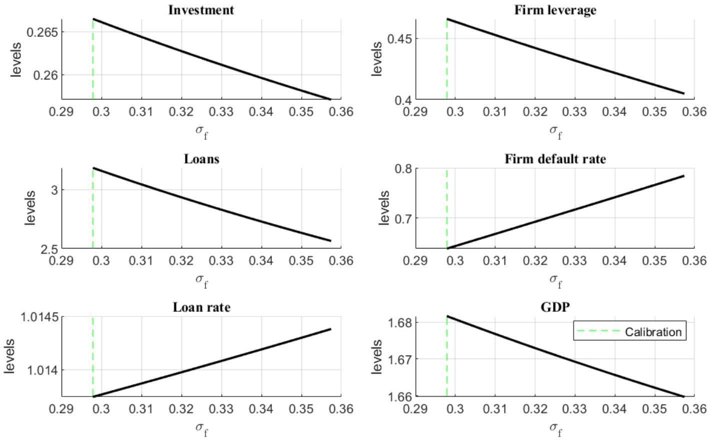
Model results

Model Setup



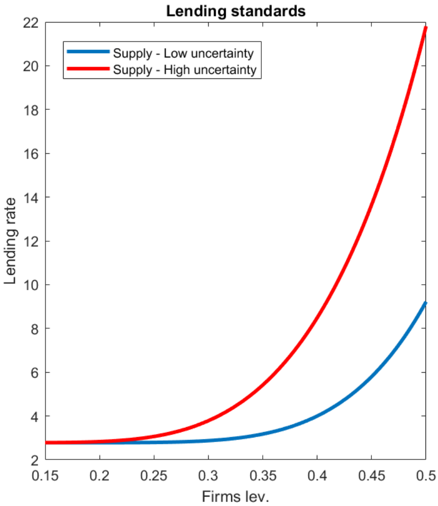
Firms
Capital Stock
Equity
Corporate Debt
Production, investment
Financial Intermediaries
Corporate Loans
Equity
Deposits
Central Bank
Monetary policy
Households
Risk-free bonds
Own funds
Deposits
Tax revenues
Bailouts
Deposit insurance

Uncertainty and Credit Market Outcomes



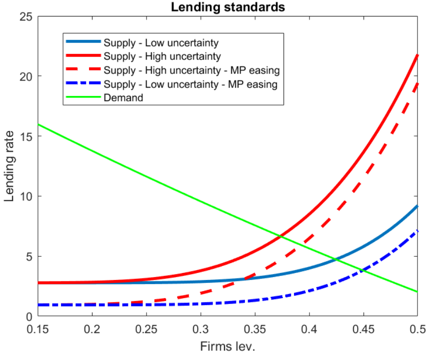
- Comparative statics for different levels of uncertainty
- Higher uncertainty associated to lower firm leverage and higher lending rates

Uncertainty and Bank Lending Standards



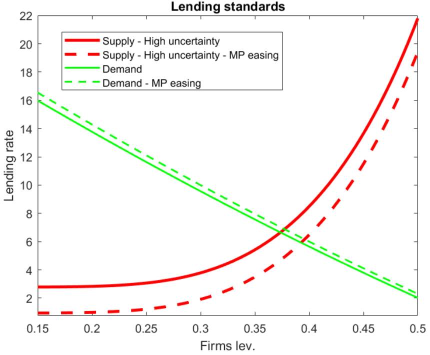
- Higher uncertainty increases borrowers default risk and make loans less profitable to banks
- The loan supply schedule becomes steeper: banks require a higher lending rate for a given firm leverage

Uncertainty and Policy Rate Changes



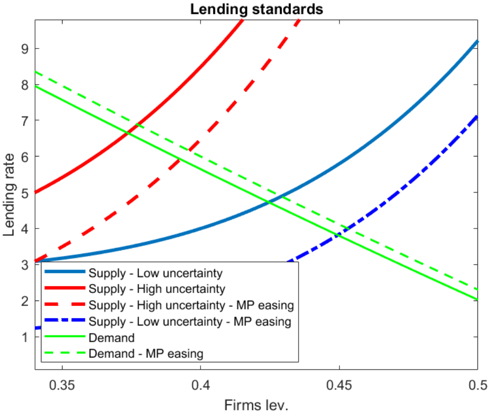
- For low firm leverage levels, the impact of the policy rate change on the loan supply schedule is independent of uncertainty

Uncertainty and Policy Rate Changes



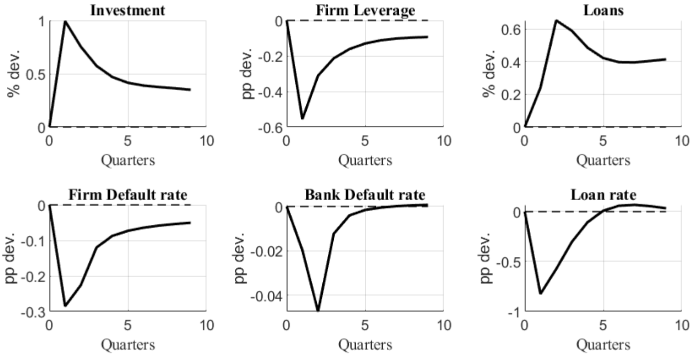
Under higher uncertainty, due to a steeper supply curve, firm leverage is less responsive and lending rates more responsive

Uncertainty and Policy Rate Changes



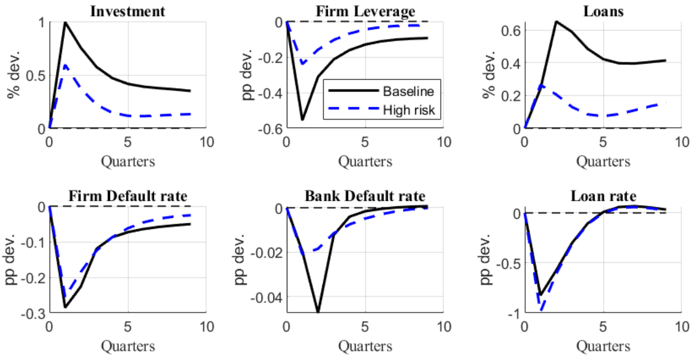
- A policy rate reduction shifts the supply curve downwards
- Under higher uncertainty, due to a steeper supply curve, imply less adjustment in quantities and more in prices
- Firm leverage is less responsive and lending rates more responsive

Monetary Policy Shocks: 100bp policy rate reduction



- Monetary policy easing improves credit market conditions, investment and reduces default risk in the economy

Monetary Policy Shocks: 100bp policy rate reduction



- Weaker transmission under higher uncertainty due to a steeper credit supply curve: credit reacts by less while lending rates react by more...
- ... and investment increases by less!

Model details

Quantitative Macro-banking Model

- Tractable **banking setup** into a **New Keynesian** framework
  - **Banks**:
    - use equity and deposits to provide loans to firms
    - s.t. capital requirements
  - **All borrowers**:
    - subject to default risk
    - operate under limited liability
  - **Policy Authority**
    - Monetary Policy: sets the short-term interest rate
- **Analysis**
  - calibrated to reproduce salient features of Euro area (1992:1-2016:4) macro, financial and banking data

Households problem

$$E_t\left[\sum_{\tau=0}^{\infty}\beta^{t+\tau}\left[\log\left(C_{t+\tau}\right)-\frac{\varphi}{1+\eta}\left(L_{t+\tau}\right)^{1+\eta}\right]\right]$$

subject to the budget constraint:

$$\begin{gathered} P_t C_t + \left(Q_t + P_t s_t\right) K_{s,t} + D_t + B_t \leq \left(P_t r_{k,t} + (1-\delta_t)\, Q_t\right) K_{s,t-1} + \\ W_t L_t + \widetilde{R}_t^d D_{t-1} + R_{t-1} B_{t-1} - P_t T_{s,t} + P_t \Pi_t + P_t \Xi_t \end{gathered} \tag{1}$$

where:

C_t: consumption

L_t: hours worked

$\widetilde{R}_t^d$: Net of default return on deposits

D_t: portfolio of deposits

$K_{s,t}$ capital held by households, subject to a cost s_t

Q_t : nominal capital price

B_t : risk free asset (in zero net supply)

R_t : Risk free rate

T_t: lump-sum tax used to ex-post balance the DIA's budget

Π_t: aggregate net transfers from entrepreneurs and bankers

Ξ_t :dividends from firms that manage the capital stock on behalf of households

Bank debt liability

- Fraction κ: **insured deposits** that always pay back the promised gross deposit rate R^d_{t-1}.
- Fraction $1 - \kappa$: **uninsured bank debt** that pays back
  - the promised rate R^d_{t-1} if the issuing bank is solvent
  - $1 - \kappa$ of the the average default loss (per unit of bank debt net recovery value of bank assets) in case of default [*Individual bank default risk not efficiently priced*]

$\Longrightarrow$ the gross return on bank debt is given by

$$\widetilde{R}^d_t = R^d_{t-1} - (1 - \kappa)\Omega_t, \tag{2}$$

For $\kappa < 1$, bank debt is overall risky: $R^d_{t-1} \geq R_{t-1}$.

Banks

Competitive sector of banks supplying loans $B_{f,t}$ to entrepreneurial firms using deposit funding D_t and equity funding $E_{b,t}$.
Max expected equity pay-off:

$$\max_{B_{f,t},D_t,E_{b,t}} \quad E_t \Lambda_{b,t+1} \max\left[\omega_{b,t+1} \widetilde{R}^b_{t+1} B_{f,t} - R^d_t D_t, 0\right]$$

$$\begin{aligned}
\text{s.t.:} \quad & E_{b,t} + D_t = B_{f,t} && \text{balance sheet constraint} \\
& E_{b,t} \geq \phi_t B_{f,t} && \text{regulatory capital constraint} \\
& E_t[\rho_{b,t+1} E_{b,t}] \geq \overline{\rho}_{b,t} E_{b,t} && \text{bankers' participation constraint}
\end{aligned}$$

where:

$\omega_{b,t+1}$: idiosyncratic portfolio return shock (mean=1)

$\widetilde{R}^b_{t+1}$: realized return on well diversified portfolio of loans to entrepreneurs

$\overline{\rho}_{b,t}$: bankers' required rate of return on equity
$\Lambda_{b,t+1}$ is bankers' stochastic discount factor

Banks (cont'd)

Banks' willingness to invest in loans with returns $\widetilde{R}^b_{t+1}$ and subject to a capital requirement ϕ_t requires having

$$E_t \Lambda_{b,t+1} \left[1 - \Gamma_{b,t+1}(\overline{\omega}_{b,t+1})\right] \widetilde{R}^b_{t+1} \geq \phi_t v_{b,t}, \tag{3}$$

which explains the expressions for the participation constraints introduced in the borrowers' problem. Rate of return on banker equity is:

$$\rho_{b,t+1} = \frac{(1 - \Gamma_b(\overline{\omega}_{b,t+1}))\widetilde{R}^b_{t+1}}{\phi_t}.$$

where

$$\Gamma_b(\overline{\omega}_{b,t}) = \int_0^{\overline{\omega}_{b,t}} \omega_{b,t} f_b(\omega_{b,t}) d\omega_{b,t} + \overline{\omega}_{b,t} \int_{\overline{\omega}_{b,t}}^{\infty} f_b(\omega_{b,t}) d\omega_{b,t}$$

is the share of bank profits that accrue to depositors

Entrepreneurial firms

The representative entrepreneurial firm gets equity A_t from entrepreneurs and borrow $B_{f,t}$ from banks at rate R_t^b to buy capital $K_{f,t}$, i.d.d. return $\omega_{f,t+1}$.

$$\max_{K_{f,t},R_t^f} E_t \left[\Lambda_{e,t+1}(1-\Gamma_{f,t+1}\left(\overline{\omega}_{f,t+1}\right))\left(\left(1-\delta_{t+1}\right)q_{t+1}+r_{k,t+1}\right)\pi_{t+1}\right]K_{f,t} \tag{4}$$

subject to:

- Budget constraint: $B_{f,t}+A_t=Q_tK_{f,t}$
- Banks participation constraint (pricing of loans for choices of firm leverage):

$$E_t\left[\underbrace{\Lambda_{b,t+1}(1-\Gamma_b(\overline{\omega}_{b,t+1}))}_{\text{LEVERED RETURNS}}\underbrace{(\Gamma^f\left(\overline{\omega}_{f,t+1}\right)-\mu_f G_f\left(\overline{\omega}_{f,t+1}\right))R_{K,t+1}}_{\text{NET RETURN ON A LOAN PORTFOLIO}}\right]q_tK_{f,t}\geq v_{b,t}\phi_t B_{f,t}$$

R_t^b such that the expected, discounted payoffs that the loans provide to bank owners (taking their limited liability into account) are large enough to compensate bankers for the opportunity cost of the equity financing contributed to such loans, $v_{b,t}\phi_t B_{f,t}$.

Entrepreneurial Firms

The representative entrepreneurial firm gets equity A_t from entrepreneurs and borrow $B_{f,t}$ from banks to buy capital $K_{f,t}$ (return affected by an i.d.d. shock $\omega_{f,t+1}$ with mean 1).

- Can optimally **default** if asset returns fall below debt repayment, in which case the banks pay a bankruptcy cost and cease the underlying asset.
- The default decision depends on both **iid** and **aggregate reasons**:

$$\omega_{f,t} \leq \overline{\omega}_{f,t} = \frac{R^f_{t-1}\frac{B_{f,t-1}}{P_{t-1}}}{R_{K,t}K_{f,t-1}}\frac{1}{\pi_t} \tag{5}$$

where $R_{K,t} = \frac{(1-\delta_t)Q_t + P_t r_{k,t}}{Q_{t-1}}$ is the aggregate nominal return on capital.

Final good producers

The final good, Y_t, is produced by perfectly competitive firms using

- $y_t(i)$ units of each type of intermediate good i
- a constant return to scale, diminishing marginal product, and constant-elasticity-of-substitution technology:

$$Y_t \leq \left[\int_0^1 y_t(i)^{\frac{1}{1+\theta}} di \right]^{1+\theta}, \tag{6}$$

where θ is the price elasticity of demand.

Intermediary goods producers

The intermediate goods, $y(i)$, is produced by monopolistically competitive firms indexed by i using the following technology

$$y(i)_t = z_t \left(l(i)_t\right)^{1-\alpha} k(i)_{t-1}^{\alpha} \ , \tag{7}$$

where k is rented capital, l is labour supplied by households.

Price rigidities as in the New Keynesian literature. At time t each intermediate firm is allowed to revise its price with probability $(1-\xi)$ as in Calvo (1983), leading to the following New Keynesian Phillips curve:

$$\log\left(\frac{P_t}{P_{t-1}}\right) = \beta\left[E_t \log\left(\frac{P_{t+1}}{P_t}\right)\right] + \epsilon_\pi \log\left(\frac{X_t}{X}\right) \tag{8}$$

where $\epsilon_\pi = \frac{(1-\xi)(1-\beta\xi)}{\xi}$ and X_t represents the marginal cost of production. Intermediate firms are owned by the households.

Monetary and Macroprudential Authority

Monetary Policy Authority : sets the short-term policy rate - Taylor Rule

$$R_t = \rho_R R_{t-1} + (1 - \rho_R) \left[\bar{R} \left(\frac{\pi_t}{\bar{\pi}} \right)^{\alpha_\pi} \left(\frac{GDP_t}{GDP_{t-1}} \right)^{\alpha_{GDP}} \right],$$

Macroprudential Authority : sets capital requirements for banks ϕ_t

Calibration

- Based on quarterly data for the Euro area (1992:1-2016:4)
- Reproduces salient features of macro, financial and banking data
- Implemented in two stages:
  1. Parameters fixable by convention
  2. Rest of parameters found so as to match targeted moments (by minimizing equally weighted sum of distances between empirical model-based moments)

Model fit

Table: Model fit

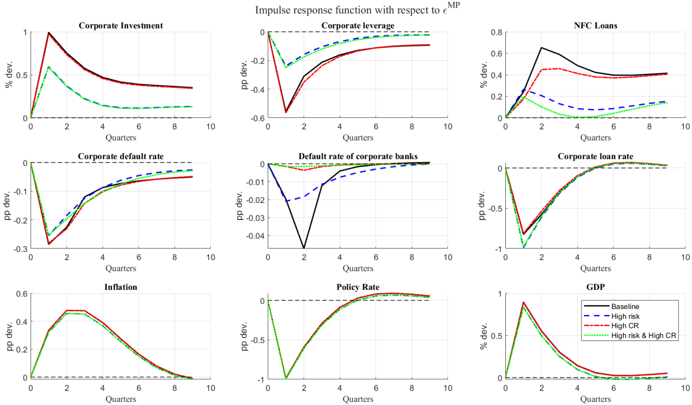
Targets	Definition	Data	Model
Real risk-free rate	$(\beta^{-1} - 1) \times 400$	2.32	2.32
Inflation	$(\overline{\pi} - 1) \times 400$	1.77	1.77
Capital requirements	ϕ	0.08	0.08
Share of insured deposits	κ	0.54	0.54
NFCs' default	$F_f(\overline{\omega}_f) \times 400$	2.646	2.556
NFC loans to GDP	b_f / GDP	1.897	1.893
Spread NFC loans	$(R^f - R) \times 400$	1.244	1.295
Banks' default	$F_b(\overline{\omega}_b) \times 400$	0.665	0.665
Real equity return of banks	$(\rho_b - 1) \times 400$	7.066	6.937
Banks price to book ratio	v_b	1.148	1.148
Capital share of households	K_s / K	0.22	0.219

Parameters

Table: Model parameters

Preset parameters					
Disutility of labor	φ	1	Banks bankruptcy cost	μ_b	0.3
Frisch elasticity of labor	η	1	Capital adjustment cost parameter	ψ_k	4.567
Capital share in production	α	0.3	Price elasticity of demand	θ	0.2
Depreciation rate of capital	δ	0.03	Calvo probability	ξ	0.75
Population of entrepreneurs	n_e	1	Smoothing parameter (Taylor rule)	ρ_R	0.75
NFC bankruptcy cost	μ_f	0.3	Inflation response (Taylor rule)	α_π	1.5
Survival rate of entrepreneurs	θ_e	0.975	Output growth response (Taylor rule)	α_{GDP}	0.1
Population of bankers	n_b	1			
Calibrated parameters					
Discount factor of consumers	β	0.994	STD iid risk for banks	σ_b	0.029
Capital requirement for banks	ϕ	0.08	Survival rate of bankers	θ_b	0.873
Share of insured deposits	κ	0.54	Transfer from HH to entrepreneurs	χ_e	0.001
Steady-state inflation	$\overline{\pi}$	1.004	Transfer from HH to bankers	χ_b	0.859
STD iid risk for entrepreneurs	σ_f	0.298	Capital management cost	ς	0.006

monetary policy with different CR



- Effects of higher CR only visible in NFC loans and Banks default

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