Monetary uncertainty and default

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Overview

Motivation

- Financial frictions have a great influence on the business cycle, as credit markets and the real economy interact with each other.
- Money and default have a close linkage with real economy.
- Policy makers have begun to treat money and default as a crucial part of their overall policy stance.

Overview
Motivation

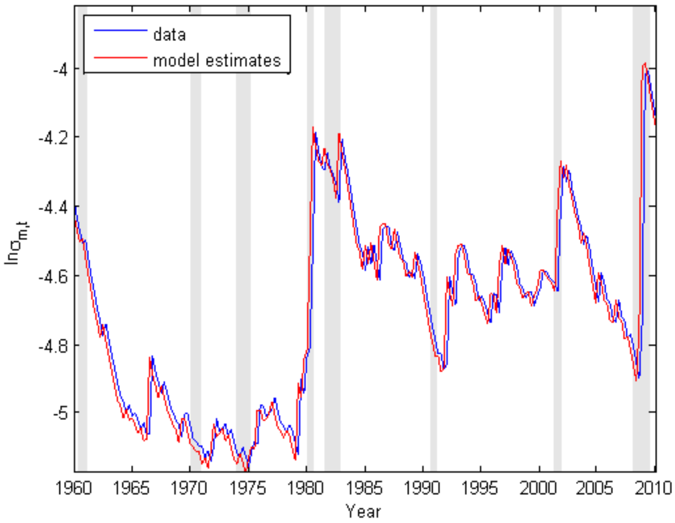

Figure 1: Estimate of monetary uncertainty

Overview
Motivation

- Uncertainty rises in recessions and falls in booms (Bloom, 2012). During recession policy becomes more uncertain, because policy makers want to do experiments (Pastor and Veronese, 2013).
- Uncertainty in policy has a negative impact on recovery through that agents become more risk averse with uncertainty (Baker et al., 2012; Stokey, 2013; Ulrich, 2013).
- Policy uncertainty and its monetary volatility could have effects on default (*On-the-Verge condition*).

Overview
Motivation

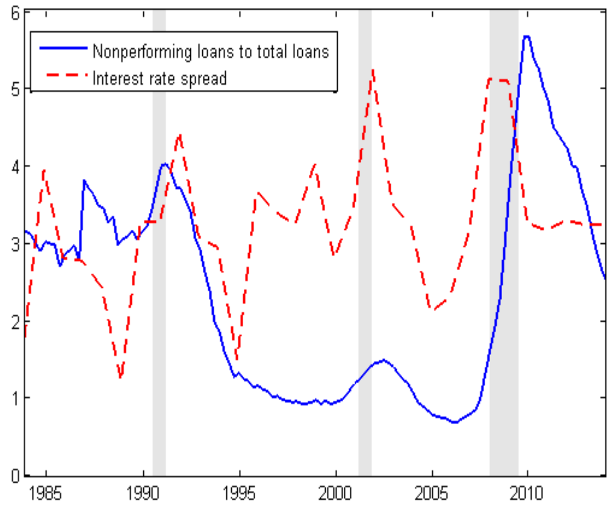

Figure 2: Default measures

Overview
Motivation

- Nonperforming loans are defined as those past due 90 days or more and still accruing call, which is a proxy for our default measure: the higher the ratio is, the more default risk is in that period.
- The interest spread is calculated as the difference between the lending rate and deposit rate from 1980 to 2013 as market data, which serves as alternative proxy for default risk measure to overcome the weakness of accounting data. It confirms the above result.

Overview
Literature review

1 **Effect of monetary policy**

- 1^{st} **moment effect**
  The tradition Keynesian view: policymakers use their leverage over short-term interest rates to affect the cost of capital, then spending on durable goods. In turn, change in aggregate demand influences the level of production.

Overview
Literature review

1 **Effect of monetary policy (cont'd)**

- 2^{st} **moment effect**
  We interpret the changes in the volatility of the innovations in the monetary policy as a representation of monetary uncertainty (Fernádez-Villaverde et al., 2011).

  Policy uncertainty has a negative impact on recovery through an understanding that agents become more risk averse when faced with uncertainty that reduces investment and lending, and thus hold back the pace of economic recovery (Baker et al., 2012; Stokey, 2013).

  Uncertainty is counter-cyclical, rising in recessions and falling in booms, and uncertainty shock works as an amplification and propagation mechanism (Bloom, 2013).

  Empirical works: Policy uncertainty caused low growth after 2011 (Baker et al., 2012).

Overview
Literature review

2 **Cash-in-advance (CIA) Constraints** (Clower, 1967)

- The agent's real spending in any given period cannot exceed the amount of real money balances the agent carried into that period.
- The possibility of default on any debt obligations underscores the necessity of CIA constraints.

3 **Endogenous default**
(Goodhart et al., 2006; Tsomocos, 2003; Bernanke nad Gertler, 1989; Shubik and Wilson, 1977)

- Money and default are incorporated into a general equilibrium model.
- Treat default by continuously allowing for partial default in equilibrium

Overview
Literature review

4 **Calculating IRF of uncertainty shock (motivation)**
(Fernandez-Villaverde et al., 2009)

- *First-order approximation* reveals only level shock in which volatility shock doesn't show up.
- *Second-order approximation* enables volatility shock only appear in the form of cross product with others, so the shock possibly have effect through the channel of others.
- *Third-order approximation* allows volatility shock only enters as an independent term in the policy functions, whose direct role can be shown.

Overview
Literature review

4 **Calculating IRF of uncertainty shock (method)**
(Fernandez-Villaverde et al., 2009; Cesa-Bianchi et al., 2014; Pfeifer et al., 2014)

(a) Draw a series of random shocks $\epsilon_t = (\epsilon_{A,t}, \epsilon_{M,t}, \epsilon_{\sigma,t})$ for 2096 periods and discard the first 2000 periods.
(b) Compute the mean of the ergodic distribution for each variable in our model based on the remaining periods.

(c) Simulate Y_t^1 starting from the ergodic mean with $\epsilon_{M,t}$ having random values and all zeros for $\epsilon_{A,t}$ and $\epsilon_{\sigma,t}$.
(d) Add one standard deviation $\epsilon_{\sigma,t}$ at period 1 while all the others unchanged.
(e) Simulate Y_t^2 from the ergodic mean with newly added shock above.
(f) IRF is equal to $Y_t^2 - Y_t^1$.

(g) We iterate the above from (c) to (f), 50,000 times and average those to calculate IRF.

Overview
Main findings

- This paper investigates the effect of monetary uncertainty on the aggregate economy, especially default.
- It assigns a monetary uncertainty shock to a dynamic general equilibrium model with default that is calibrated with U.S. economy and it is solved using a 3^{rd} perturbation method.
- It reveals that monetary uncertainty has a negative effect on the economic activity and results in default issue.
- The transmission channel from monetary uncertainty to default:
  - An increase of risk aversion among agents is the primary cause of investment delays and dries up liquidity temporarily.
  - A decrease in the output serves as an intermediate step in the transmission mechanism of monetary uncertainty.

Overview
Main findings

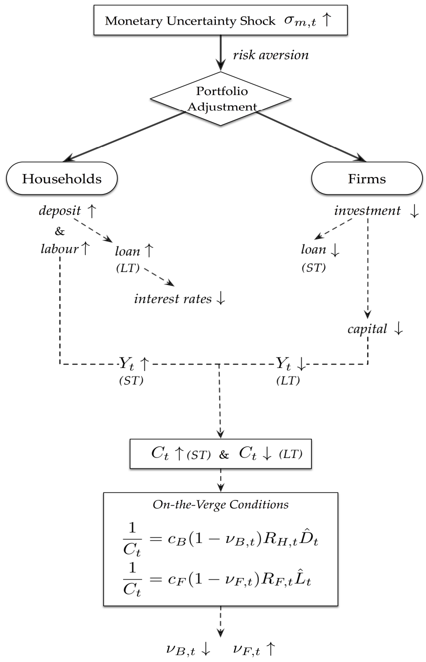

Figure 3: Transmission channel of monetary uncertainty

The Model
Notes on model with default

- We introduce an endogenous default via CIA constraints and also model default through repayment rate of banks and firms, respectively: $\nu_{B,t}$ and $\nu_{F,t}$, which denotes the proportion the agent actually pay back.
- Non-pecuniary default penalty: The cost of default is modelled by a penalty that reduces agents' utility.
- Adopt a quadratic form of non-pecuniary penalty that allows for time-varying consumption levels and for a positive correlation between the repayment rate and consumption.

The Model

Notes on model with default

- How to construct?
  - Assume a proportional relationship between the amount of default and reputation loss (Tsomocos 2003).
  - Assume coefficient for default penalty $c_{F,t}$ is a function of the state of the agent such as consumption level and amount of default.
  - Thus the final form of default penalties is quadratic for both firms and banks.

The Model

General description

- Christiano (1991), Christiano and Eichenbaum (1992), Nason and Cogley (1984)
  - Three optimising agents: Household, Bank and Firm
  - One strategic dummy: Central Bank
  - At the beginning of period t, the representative household inherits the entire money stock of the economy M_t, and the aggregate price level is denoted by P_t.

Equilibrium analysis
Market clearing conditions

- **Credit market:** $B_t = \nu_{F,t} R_{F,t} L_t - \nu_{B,t} R_{H,t} D_t$
  Dividend of banks is defined by the difference between the size of corporate loans and that of deposits with corresponding interest rate, and is adjusted by payment rates.
- **Labor market:** $H_t = N_t$
  The labor supply equals the labor demand.
- **Money market:** $P_t C_t = M_{t+1}$
  Money demand, deliminated by nominal consumption demand, is equated with money supply.
- **Goods market:** $C_t + K_{t+1} - (1-\delta) K_t = K_t^{\alpha} (A_t N_t)^{1-\alpha}$
  Output equals consumption plus investment.

Equilibrium analysis
Optimality conditions

Households

- Intertemporal labor market optimality condition links labor supply, the marginal rate of substitution between leisure and consumption, and labor demand.

$$\frac{L_t}{N_t} = \frac{\phi C_t P_t}{(1-\phi)(1-N_t)}$$

- The Euler equation refers the households' loss in current consumption from increasing its deposits in the bank matches the discounted expected gain, adjusted for default of banks, in the future consumption from the deposit.

$$\frac{1}{R_{H,t}} = \beta E_t \left(\frac{\nu_{B,t} C_t P_t}{C_{t+1} P_{t+1}} \right)$$

Equilibrium analysis

Optimality conditions

Firms

- Optimality suggests the intertemporal consumption trade-off is in terms of marginal utility one period ahead weighted by the purchasing power of money.

$$E_t\left(\frac{P_t}{C_{t+1}P_{t+1}}\right) = E_t\left(\frac{\beta P_{t+1}}{C_{t+2}P_{t+2}}\left(\alpha K_{t+1}^{\alpha-1}\left(A_{t+1}N_{t+1}\right)^{1-\alpha} + (1-\delta)\right)\right)$$

- The firm equates the increase in its nominal revenue generated by an extra unit of labor to the nominal cost for the unit of the labor.

$$(1-\alpha)\, P_t Y_t = \frac{c_F\, C_t\left[\left(1-\nu_{F,t}\right) R_{F,t} L_t\right]^2}{A_t M_t} + \nu_{F,t} R_{F,t} L_t$$

- The optimal default decision for the firms is suggested when the marginal utility of consumption equals the marginal loss from default.

$$\frac{1}{C_t/A_t} = c_F\left(1-\nu_{F,t}\right) R_{F,t}\frac{L_t}{M_t}$$

Equilibrium analysis

Optimality conditions

Banks

- When the marginal gain from default equals the marginal loss from default, banks' optimal decision of default occurs.

$$\frac{1}{C_t/A_t} = c_B\left(1-\nu_{B,t}\right) R_{H,t}\frac{D_t}{M_t}$$

- If banks lend what they borrowed from household to firms, banks compensate for the borrowing cost of earning from this transaction.

$$\nu_{F,t} R_{F,t} - \nu_{B,t} R_{H,t} = \frac{c_B\, C_t\left(1-\nu_{B,t}\right)^2 R_{H,t}^2 D_t}{A_t M_t}$$

Equilibrium analysis

Propositions

Proposition 1: Fisher equation

$$\log R_{H,t} \approx \log E_t \left(\frac{U'_{C_t}}{\beta U'_{C_{t+1}}} \right) + \log E_t \left(\pi_{t+1} \right) + \log \frac{1}{\nu_{B,t}}.$$

The nominal interest rate is approximately equal to the real interest rate plus risk premium such as inflation risk and default risk.

Proposition 2: Quantity theory of money

$$\frac{P_t Y_t}{M_{t+1}} = 1 + \frac{P_t I_t}{M_{t+1}}.$$

The Quantity Theory of Money doesn't hold in the short run. The investment decision is distorted by money policy and this distortion is transmitted into the real economy. The non-trivial role of money is thus confirmed.

Equilibrium analysis

Propositions

Proposition 3: On-the-verge conditions

$$\begin{aligned} U_{C_t} &= c_B \left(1 - \nu_{B,t}\right) R_{H,t} \hat{D}_t, \\ U_{C_t} &= c_F \left(1 - \nu_{F,t}\right) R_{F,t} \hat{L}_t. \end{aligned}$$

The optimal amount of default is defined when the marginal utility of default equals the marginal disutility of it whenever firms or banks make a default decision.

Proposition 4: Relative structure of interest rates

$$\nu_{F,t} R_{F,t} = R_{H,t}.$$

The only wedge between interest rate of loans and deposit rate is driven by repayment rate of firm. The lower the repayment rate is, the riskier the loans to firms becomes from banks' perspective.

Calibration

Parameterisation

Table 1: Implied parameters

Description	Parameter	Value
Output elasticity of capital	α	0.320
Discount factor	β	0.990
AR(1) coefficient of technology	ρ_A	0.950
Smoothing coefficient of monetary uncertainty	ρ_σ	0.964
AR(1) coefficient of money supply growth	ρ_m	0.653
MRS between leisure and consumption	ϕ	0.773
Depreciation rate	δ	0.025
Default penalty for banks	c_B	448.95
Default penalty for firms	c_F	267.75

Calibration

Parameterisation

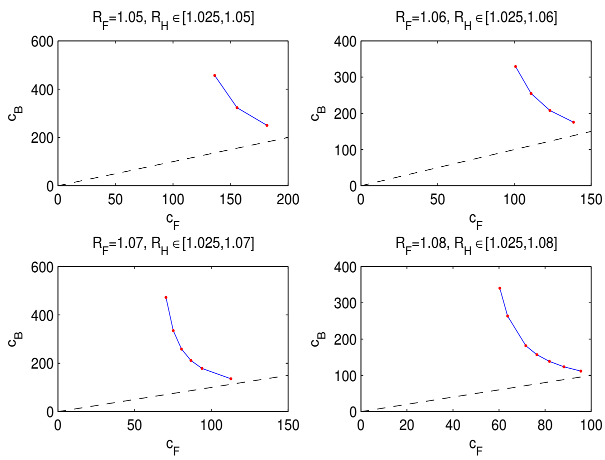

Figure 4: Sensitivity analysis of $\bar{R}_H$ and $\bar{R}_F$ according to c_B and c_F

Fixing interest rate for loans to firms, we increase the deepest interest rate by 0.0025 step and draw the graph of the default penalty for bank and firms.

Calibration

Parameterisation

Model without default

- Repayment rate for bank and firm, i.e. $\nu_{B,t}$ and $\nu_{F,t} = 1$.
- There is no reputation loss in the utility function for bank and firm.
- Thus, c_B and c_F are arbitrary.

Quantitative analysis

Steady state implication of default

Table 2: Steady state of the model

Description	Parameter	Without default	With default
Logarithm of monetary growth rate	$g\bar{M}$	0.0136	0.0136
Price of goods	$\bar{P}$	2.3012	2.3300
Consumption	$\bar{C}$	0.4405	0.4351
Wage per worker	$\bar{W}$	4.3239	4.3104
Capital used for production	$\bar{K}$	5.2014	5.1371
Interest rate for loans to firms	$\bar{R}_F$	1.0239	1.0400
Interest rate for deposit to banks	$\bar{R}_H$	1.0239	1.0300
Deposits from households	$\bar{D}$	0.8582	0.8448
Loans to firms	$\bar{L}$	0.8719	0.8585
Labor used for production	$\bar{N}$	0.2017	0.1992
Output	$\bar{Y}$	0.5705	0.5635
repayment rate of banks	$\bar{\nu}_B$	1	0.9941
repayment rate of firms	$\bar{\nu}_F$	1	0.9904

Quantitative analysis
Costs of monetary uncertainty

Exogenous process of monetary uncertainty

- The innovation $\chi\sigma_{m,t}\epsilon_{m,t}$ has a time-varying standard deviation $\chi\sigma_{m,t}$, i.e. stochastic volatility of money growth rate as a proxy for monetary uncertainty. It stochastically moves period by period according to the autoregressive processes (Fernández-Villaverde,2010).

$$\ln \sigma_{m,t} = \rho_\sigma \ln \sigma_{m,t-1} + (1-\rho_\sigma) \ln \bar{\sigma}_m + \eta_\sigma \epsilon_{\sigma,t}$$

Quantitative analysis
Costs of monetary uncertainty

IRFs of monetary uncertainty shock

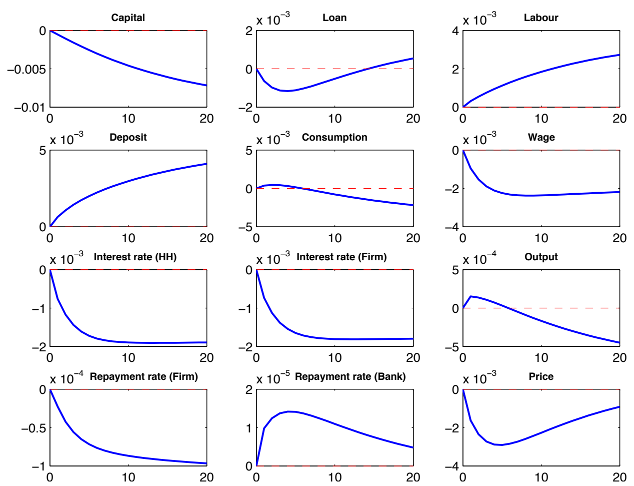

Figure 5: IRFs of monetary uncertainty shock

Quantitative analysis
Costs of monetary uncertainty

First stage: monetary uncertainty leads to less output.

- Agents become more risk averse when they face with uncertainty and adjust their portfolio (Pastor and Veronesi, 2012; Baker et al., 2012).
- Firms delay investment in the short run, which leads to decreased capital stock (Stokey, 2013).
- Households work harder and deposit more for precautionary purposes and consume less (Pastor and Veronesi, 2012).
- Output decreases due to decreased capital and demand for goods.

Quantitative analysis
Costs of monetary uncertainty

Second stage: the default rates of banks and firms are influenced.

- Default rate of firms increase and default rate of banks decrease. (‘On-the-Verge Conditions,’ Proposition 3)
- Banks increase the repayment rate at the cost of more debt.
- A counter-cyclical risk premium can be seen through the increased default rate of firm in the recession (Bloom, 2012).

Concluding remark

What we did

We employ a general equilibrium model with heterogeneous agents and financial frictions to analyse the impact of monetary uncertainty on economic activities, especially default.

We interpret the changes in the volatility of the innovations in the monetary policy as a presentative of monetary uncertainty (Fernádez-Villaverde et al., 2011).

- Increased monetary uncertainty causes portfolio adjustment of agents due to their risk aversion.
- Households deposit more while investment from firms is delayed.
- Output drops and default rate of firms climbs while that of banks drops at the cost of carrying more debts.
- Monetary uncertainty has an overall negative effect on the economy generally, which is in line with current research on policy uncertainty (Baker et al. 2012; Stokey, 2013; Fernádez-Villaverde et al., 2011; Bloom, 2013).

Concluding remark

Contributions

- First attempt to study the implication of monetary uncertainty on default as an equilibrium phenomenon.
- A supplement to the types of volatility shock.
- Monetary uncertainty is considered in a framework of endogenous default.
- Presents monetary policy implications for the government to adopt more stable money supply policy to avoid the de-stability effects.

Concluding remark
Future research

- Consider the effects of heterogeneity at the level of banks to expand transmission channel of monetary uncertainty via adding interbank market.
- Investigate more specific monetary policy rules such as the regime switching model.
- Model default in a broader way: introduce default on secured loans which leads to the loss of collateral.

Appedix
A. The Model

- Household determines how much money D_t to deposit which earns interest rate at $R_{H,t}$ in the bank, and receive dividend F_t from firm's net cash flows, its deposit inclusive of interest and net cash flow from the bank as B_t, besides it consumes the goods firms produce while providing the labors.
- Firm produces and hires labor services from the households, then uses money borrowed from bank to pay for the wages $W_t H_t$ and dividend to households
- The bank receives household deposits and a monetary injection X_t from the central bank, which it lends to the firm at rate $R_{F,t}$

Household's optimisation

- In period t, the household chooses consumption C_t, hours worked H_t, and non-negative deposits D_t to maximize the expected sum of discounted future utility.

$$\max_{\{C_t, H_t, M_{t+1}, D_t\}} \quad E_0 \sum_{t=0}^{\infty} \beta^t \left\{(1-\phi)\ln C_t + \phi \ln(1-H_t)\right\}$$

$$s.t.$$

$$P_t C_t \leq M_t - D_t + W_t H_t$$
$$M_{t+1} = (M_t - D_t + W_t H_t - P_t C_t) + \nu_{B,t} R_{H,t} D_t + F_t + B_t$$

Appedix
A. The Model

Household's optimisation (cont'd)

- The first constraint spells out the CIA constraint including wage revenues.
- The second spells out the inability to borrow from the bank.
- The third spells out the intertemporal budget constraint emphasizing that households accumulate the money from total inflows made up of the money they receive from firms F_t and from banks B_t.

Firm's optimisation

- The firm chooses the next period's capital stock K_{t+1}, labor demand N_t, dividends F_t and loans L_t. Date t nominal dividends are discounted by date $t+1$ marginal utility of consumption as households value a unit of nominal dividends in terms of the consumption it enables during period $t+1$, and the non-pecuniary default penalty describes the reputation cost in the firm's utility function.

$$\max_{\{F_t, K_{t+1}, N_t, L_t, \nu_{B,t}\}} \quad E_0 \sum_{t=0}^{\infty} \frac{\beta^{t+1}}{C_{t+1} P_{t+1}} \left\{ F_t - \frac{c_F}{2} \frac{C_t}{A_t M_t} \left[\left(1 - \nu_{F,t}\right) R_{F,t} L_t \right]^2 \right\}$$

$$s.t.$$

$$W_t N_t \leq L_t$$

$$F_t = L_t + P_t \left[Y_t - K_{t+1} + (1-\delta) K_t \right] - W_t N_t - \nu_{F,t} L_t R_{F,t}$$

Firm's optimisation (cont'd)

- The first constraint the firm faces reflects the fact that the firm finances its current period wage bill $W_t N_t$ by borrowing L_t.
- The second constraint says that the firm balances paying the household larger dividends or accumulating more capital.

Bank's optimisation

- The bank maximizes the expected infinite horizon discounted stream of dividends it pays to households

$$\max_{\{B_t, L_t, D_t, \nu_{B,t}\}} \quad E_0 \sum_{t=1}^{\infty} \frac{\beta^{t+1}}{C_{t+1}P_{t+1}} \left\{ B_t - \frac{c_B}{2}\frac{C_t}{A_t M_t}\left[\left(1-\nu_{B,t}\right) R_{H,t} D_t\right]^2 \right\}$$

$s.t.$

$$L_t \leq X_t + D_t$$
$$B_t = D_t + \nu_{F,t} R_{F,t} L_t - \nu_{B,t} R_{H,t} D_t - L_t + X_t$$

Bank's optimisation (cont'd)

- $X_t = M_{t+1} - M_t$ is the monetary injection.
- Banks receive cash deposits D_t from households and a cash injection X_t, then use these funds to disburse loans to the firms L_t, which earn a return of $R_{F,t}$.
- The second constraint simply defines the cash flow balances of the bank.

Appedix

B. Calibration

$$\ln A_t = \rho_A \ln A_{t-1} + (1 - \rho_A) \ln \bar{A} + \sigma_A \epsilon_{A,t}$$

Table 3: Implied parameters for technology process

Description	Parameter	Value	Source
AR(1) coeffficents of technology	ρ_A	0.950	Cooley and Prescott
Standard deviation of technology shock	σ_A	0.007	(1995)
Steady state of TFP	$\bar{A}$	1.000	normalised

Appedix

B. Calibration

$$\ln m_t = \rho_m \ln m_{t-1} + (1 - \rho_m) \ln \bar{m} + \chi \sigma_{m,t} \epsilon_{m,t}$$

Table 4: Estimate results for monetary policy

Description	Parameter	Standard error	p-Value
Constant	0.0047	0.0001	$< 10^{-4}$
AR(1) coefficient ρ_m	0.6534	0.0516	$< 10^{-4}$
RMSE	0.0098		
R-square	0.4260		

Appedix

B. Calibration

$$\ln \sigma_{m,t} = \rho_\sigma \ln \sigma_{m,t-1} + (1-\rho_\sigma) \ln \bar{\sigma}_m + \eta_\sigma \epsilon_{\sigma,t}$$

Table 5: Estimate results for monetary uncertainty

Description	Parameter	Standard error	p-Value
Constant	-0.1675	0.0904	0.0653
AR(1) coefficient ρ_σ	0.9639	0.0193	$< 10^{-4}$
RMSE	0.0891		
R-square	0.921		

Appedix

C. Cyclical properties (quantitative analysis)

Two exogenous processes for TFP and monetary policy

- Technology follows a stationary AR(1) process, ρ_A is AR(1) coefficient of technology and $\bar{A}$ indicates the steady state of technology.

$$\ln A_t = \rho_A \ln A_{t-1} + (1-\rho_A) \ln \bar{A} + \sigma_A \epsilon_{A,t}$$

- The money stock M_t grow at rate $m_t = M_{t+1}/M_t$. m_t is a shifter to intertemporal money.

$$\ln m_t = \rho_m \ln m_{t-1} + (1-\rho_m) \ln \bar{m} + \chi \sigma_{m,t} \epsilon_{m,t}$$

Appedix
C. Cyclical properties (quantitative analysis)

IRFs of technology innovation

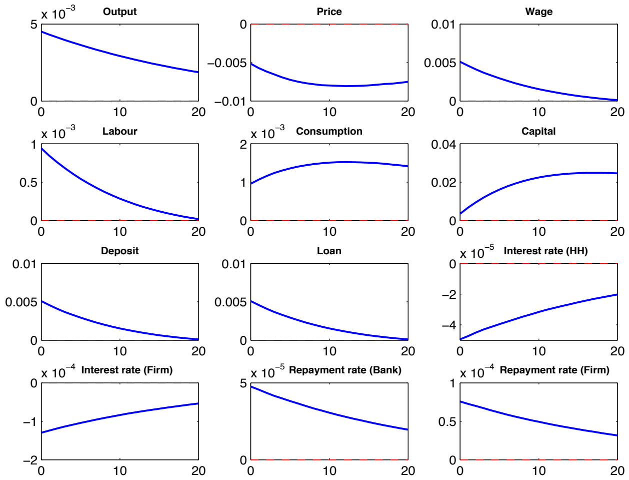

Figure 6: IRFs of positive technology innovation

Appedix
C. Cyclical properties (quantitative analysis)

IRFs of monetary policy

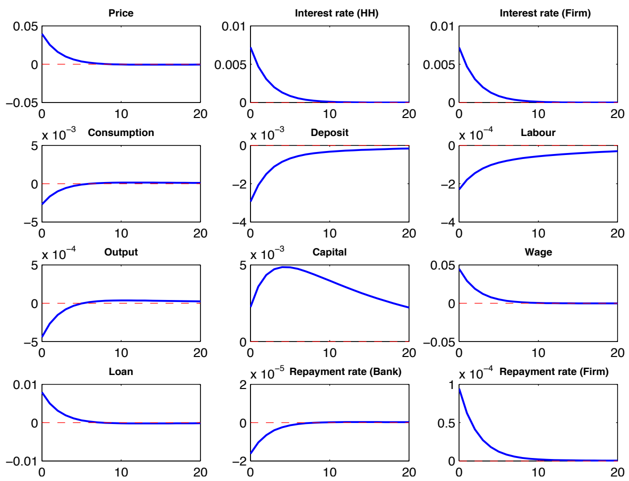

Figure 7: IRFs of positive money growth shock

Appedix

C. Cyclical properties (quantitative analysis)

Three Hypotheses are confirmed by IRFs of technology innovation and of monetary policy shock:

- Financial accelerator effect (Bernanke et al., 1999)
- Countercyclical risk premium
  (Gourio, 2012; Zhang, 2005; Stireletten, 2007)
- Procyclical property of loans
  (Foos, 2009; Tabak, 2011; Stolz and Wedow, 2011)

Non-trivial role of financial frictions, i.e. money and default, is confirmed by IRFs of monetary policy shock.