Money Creation and Banking: Theory and Evidence

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Introduction

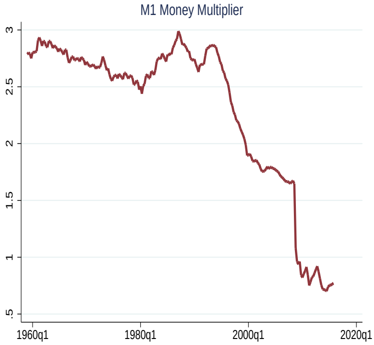
- What determines the money multiplier?

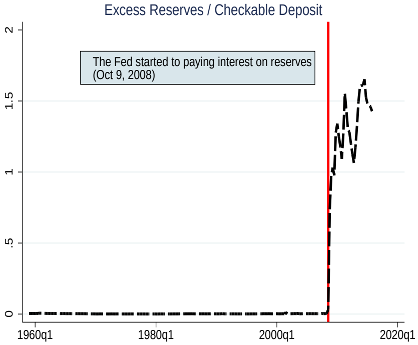
- Motivations
  - since 2008, banks hold large excess reserves.
    (required reserves ratios are zero, since March 26th 2020)
  - relationship between the money multiplier and the required reserve ratio is not clear in the data even before 2008.

- This paper
  - a profit maximizing bank creates inside money and determines whether to hold excess reserve endogenously.
  - credit conditions matter for the money multiplier.
  - different means of payments.

Motivation

Drop in Money Multiplier & Large Excess Reserves

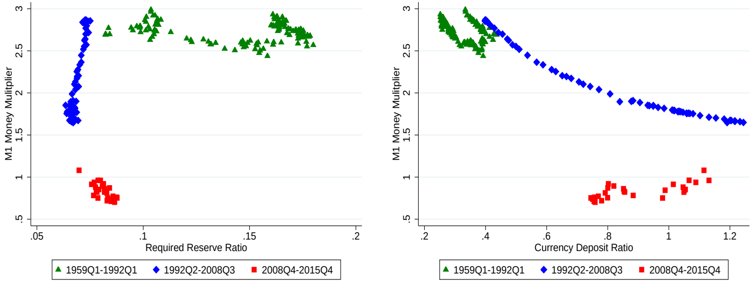




$$\text{M1 Money Multiplier} = \frac{\text{M1}}{\text{Monetary Base}} = \frac{\text{Currency} + \text{CheckableDeposit}}{\text{Monetary Base}}$$

Motivation

Money Multiplier & Required Reserves Ratio



$$\frac{M1}{MB} = \frac{C+D}{C+R} = \frac{C/D+1}{C/D+R/D} = \frac{cd+1}{cd+req}$$

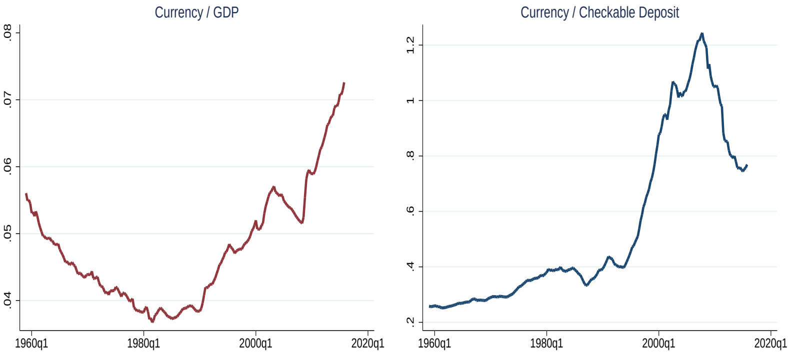
when banks are not holding excess reserves

- currency-deposit ratio (cd) determined by the public.
- required reserves ratio (req) determined by a central bank

Chow test for structural break

Motivation

Increase of Currency in Circulation



Demand for Currency

Motivation

- Banks are holding excess reserves since 2008
- There is no negative relationship between money multiplier and required reserve ratio even pre-2008 period when banks are not holding excess reserves
- Negative relationship between money multiplier and currency deposit ratio disappeared since 2008
- Currency-output ratio of US economy is higher than ever since 1960
- More physical currency than checkable deposits from 2002Q2 to 2010Q1

⇒ Can monetary theory explain these observation and money creation process?

This paper

I construct a search model of money and credit with fractional reserve banking:

- identify conditions and policies that characterize when banks hold excess reserves.
- identify effect of credit condition.

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  1. ample-reserves, 2. scarce-reserves, 3. no-banking

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- interest rate is not too small $\rightarrow$ scarce-reserves
  interest rate is small & interest on reserve $\rightarrow$ ample-reserves
- calibrated model can generate many features of the evolution of money multiplier in the data.

Key ingredients

- Bank's lending constraint.
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  - consider zero-excess reserves (bank's lending constraint binds)

$$\begin{aligned} \mathrm{M} &= \mathrm{C} + \frac{\text{Reserves}}{\text{Reserve Requirement (RR)}} \\ &= \underbrace{\mathrm{C} + \text{Reserves}}_{\text{Base Money}} + \underbrace{\text{Reserves} \times \left(\frac{1}{\mathrm{RR}} - 1\right)}_{\text{Created Inside Money through Lending}} \end{aligned}$$

- Interaction of money and credit.

Key ingredients

- Bank's lending constraint.
  - consider zero-excess reserves (bank's lending constraint binds)
  - consider bank's profit maximization

$$\max_{\text{lending, other control vars}} \text{Bank's Profit}$$

$$s.t. \quad \underbrace{\text{Reserves} \times \left(\frac{1}{\text{RR}} - 1\right)}_{\text{lending limit}} \underbrace{\geq}_{=?} \text{lending} = \text{created inside money}$$

  - Doesn't need to bind. This need to be endogenous.

- Interaction of money and credit.

Key ingredients

- Bank's lending constraint.
- Interaction of money and credit.
  - follow Gu et al. (2016, ECTA)
    - credit is a substitute for money
    - an increase in credit only crowds out the real balance of money.

Related Literature

- Money and credit:
  Gu et al. (2016, ECTA) Lotz & Zhang (2016, JET), Wang et al. (2019, IER), Bethune et al. (2020, REStud),

- Inside money and banking:
  Freeman & Huffman (1991, IER), Berentsen et al. (2007, JET), Gu et al. (2013, REStud), Berentsen et al. (2015, REStud)

Model

Environment

- Time, goods
- Buyers, sellers
- Preferences

Environment

- Time, goods
  1. $t = 0, 1, 2..., \infty$
  2. Each period has two subperiod:
     - Centralized Market (CM)
     - Decentralized Market (DM): bilateral trade, subject to anonymity, limited commitment
  3. Perishable DM/CM goods.

- Buyers, sellers

- Preferences

Environment

- Time, goods
- Buyers, sellers
  1. Buyer: measure 1; maximize life time utility;
  2. Seller: measure 1; maximize life time utility;
- Preferences

Environment

- Time, goods
- Buyers, sellers
- Preferences

$$\text{Buyer: } U(X) - H + u(q)$$

$$\text{Seller: } U(X) - H - c(q)$$

  - CM consumption X; CM disutility for production H; DM consumption q; discount factor: β
  - efficient DM consumption, q^* solves $u'(q^*) = c'(q^*)$.

Different DM meetings

1. DM1: sellers only accept cash
2. DM2: sellers accept cash / claim on deposits / private bank note
3. DM3: sellers accept cash / claim on deposits / private bank note / unsecured credit
   (buyer's unsecured credit limit is exogenously given by $\bar{\delta}$)

- Type j DM meeting with prob σ_j
- $\sigma_1 + \sigma_2 + \sigma_3 = 1$
- In the CM, agents get to know which DM meeting they are going to

Bank

- A representative bank; max profit in each period;
- accepts deposits, d;
  issues claims on deposit (give deposit rate, i_d);
  can keep deposits as reserves, r;
  may earn some interest on reserves $i_r \geq 0$
- lends bank loans ℓ by issuing private banknotes $b = \ell$;
  earns interest i_l
- lending is constrained by reserves and reserve requirement;

$$\ell \leq \bar{\ell} = \frac{1-\chi}{\chi} r$$

- cost for operating claims on deposit, k;
- costly enforcement to repay ℓ, $\eta(\ell) = \nu \ell^{\alpha}$ where $\alpha > 1$;

Central bank

- M is monetary base issued by the central bank.
- M is distributed to the economy in two ways: (1) C as cash in circulation; (2) R as reserves hold by banks.

$$M = C + R$$

- i_r: interest on reserves; μ: money growth rate; T: lump-sum transfer (or tax); ϕ: price of money in terms of CM consumption good;
- The central bank's budget constraint can be written as

$$\mu\phi M = \phi(M - M_{-1}) = T + i_r \phi R$$

DM trade

- Bargaining is characterized by payment and quantity (p, q).

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- Kalai (1977)'s proportional bargaining

$$\max u(q) - p \quad s.t \quad u(q) - p = \theta\,[u(q) - c(q)]$$

- $\theta \in [0, 1]$ denotes the buyers' bargaining power.

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- Define *liquidity premium*, $\lambda(q)$, as following

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$$\lambda(q) = \frac{u'(q)}{v'(q)} - 1 = \frac{\theta[u'(q) - c'(q)]}{(1 - \theta)u'(q) + \theta c'(q)}, \quad \lambda'(q) < 0$$

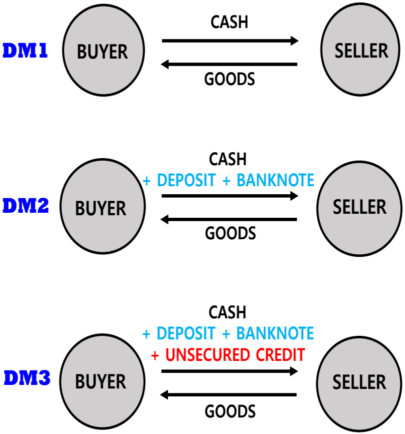
DM trade

- Payment p is constrained by their liquidity position z.

$$\begin{aligned} v(q_1) &= p_1 \leq z_1 = m_1 \\ v(q_2) &= p_2 \leq z_2 = m_2 + d_2(1 + i_d) + b_2 \\ v(q_3) &= p_3 \leq z_3 = m_3 + d_3(1 + i_d) + b_3 + \bar{\delta} \end{aligned}$$

- Let p^* be a payment to get q^* with $p^* = v(q^*)$.
- When $z_j > p^*$, $p_j = p^*$ and when $z_j < p^*$, $p_j = z_j$.
- m: cash; d: deposit; $\bar{\delta}$: unsecured credit limit;
  b: private banknote issued by a bank; i_d: deposit rate;

Decentralized Market



Centralized Market

BUYER

- Realize their next DM meeting type
- Work & consume
- Redeem deposit with interest, $(1+i_d)d_j$
- Repay loans $(1+i_l)l_j$ & unsecured credit δ
- Acquire & adjust balance
  - cash m_j
  - deposit d_j to bank
  - acquire banknote b_j by borrowing $l_j = b_j$ from bank

Period t

Buyers' CM problem

CM value function for buyer

$$W^B(m,d,b,\ell,\delta) = \sum \sigma_j W_j^B(m,d,b,\ell,\delta)$$

CM value function for j type DM meeting buyer

$$W_j^B(m,d,b,\ell,\delta) = \max_{X,H,\hat{m}_j,\hat{d}_j,\hat{\ell}_j,\hat{b}_j} U(X) - H + \beta V_j^B(\hat{m}_j,\hat{d}_j,\hat{b}_j,\hat{\ell}_j)$$

subject to

$$(1+\pi)\hat{m}_j + (1+\pi)\hat{d}_j + X = m + (1+i_d)d + b - \delta - (1+i_l)\ell + H + \tau$$

$$\hat{b}_j = \hat{\ell}_j$$

π: inflation rate; τ: lump-sum transfer/tax to buyer;

DM1 buyer's problem

$$
\begin{aligned}
V_1^B(m, d, b, \ell) &= u(q) + W^B(m - \tilde{m}, d, b, \ell, 0) \\
p &= \tilde{m}
\end{aligned}
$$

DM1 buyer's problem

$$\begin{aligned} V_1^B(m, d, b, \ell) &= u(q) + W^B(m - \tilde{m}, d, b, \ell, 0) \\ p &= \tilde{m} \end{aligned}$$

DM1 buyer's DM trade surplus

$$\Delta = u(q) + W^B(m - \tilde{m}, d, b, \ell, 0) - W^B(m, d, b, \ell, 0)$$

DM1 buyer's problem

$$V_1^B(m, d, b, \ell) = u(q) + W^B(m - \tilde{m}, d, b, \ell, 0)$$
$$p = \tilde{m}$$

DM1 buyer's DM trade surplus

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Intermediate result: $\hat{d}_1 = \hat{\ell}_1 = \hat{b}_1 = 0$

DM2 & DM3 buyer's problem

DM2 value function

$$V_2^B(m, d, b, l) = u(q) + W^B(m - \tilde{m}, d - \tilde{d}, b - \tilde{b}, \ell, 0)$$

$$\text{where } p = \tilde{m} + (1 + i_d)\tilde{d} + \tilde{b}$$

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DM3 value function

$$V_3^B(m,d,b,l) = u(q) + W^B(m-\tilde{m}, d-\tilde{d}, b-\tilde{b}, \ell, \delta)$$

$$\text{where } p = \tilde{m} + (1+i_d)\tilde{d} + \tilde{b} + \delta \qquad \delta \leq \bar{\delta}$$

DM2 & DM3 buyer's problem

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Intermediate result: $\hat{m}_2 = \hat{m}_3 = 0$ when $i_d > 0$

Bank's problem

- A risk-neutral rep. bank max its profit by receiving deposits and lending loans.

FOCs

Bank's problem

- A risk-neutral rep. bank max its profit by receiving deposits and lending loans.

$$\max_{r,d} \quad (-i_d \quad)d$$

- interest on reserves i_r. deposit operating cost k. loan, ℓ, enforcement cost $v\ell^\alpha$

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$$\max_{r,d,\ell} \quad i_r r + (-i_d - k)d + i_l \ell$$

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$$s.t. \;\; r \leq d \quad \& \quad \underbrace{\frac{1-\chi}{\chi} r}_{\text{lending limit}} \geq \ell$$

- interest on reserves i_r. deposit operating cost k. loan, ℓ, enforcement cost $v\ell^{\alpha}$

FOCs

Bank's problem

- $r = d$
- Two cases

1. bank's lending is not binding.

$$0 = i_r - i_d - k \tag{1}$$
$$0 = i_l - \alpha v \ell^{\alpha-1} \tag{2}$$

$$\ell^* = \left(\frac{i_l}{\alpha v}\right)^{\frac{1}{\alpha-1}} \quad : \text{supply for loan where } \ell^* < \bar{\ell} = \frac{1-\chi}{\chi} d$$

2. bank's lending is binding.

$$0 = i_r - i_d - k + \left[i_l - \alpha v \left(\frac{1-\chi}{\chi} d \right)^{\alpha-1} \right] \frac{1-\chi}{\chi} \tag{3}$$

back to bank's problem

Definition of equilibrium

Focus on stationary equilibrium where real balances are constant $m = m^+$, $r = r^+$. $\pi = \mu$. $i \equiv (1+\mu)/\beta - 1$.

Given monetary policy, (i, i_r, χ) and credit limit $(\bar{\delta})$, a stationary monetary equilibrium is consists of

- real quantities $(m_j, d_j, \ell_j)_{j=1}^{3}$,
- consumption quantities (q_1, q_2, q_3),
- prices (i_l, i_d),

satisfying the following:

1. $(i_d, i_l, q_1, q_2, q_3)$ solves agents' problem and bank's problem
2. The bank lending constraint satisfies, $\ell = \min(\bar{\ell}, \ell^*)$ where $\bar{\ell} = \frac{1-\chi}{\chi} r$ and $\ell^* = \left(\frac{i_l}{\alpha v}\right)^{\frac{1}{\alpha - 1}}$
3. Asset markets clear

Three types of equilibrium

- $\ell^* \geq \bar{\ell} > 0$: A scarce-reserves equilibrium

$$\ell = \bar{\ell} = \frac{1-\chi}{\chi} r < \ell^*$$

- $\bar{\ell} > \ell^* \geq 0$: A ample-reserves equilibrium

$$\ell = \ell^* < \bar{\ell} = \frac{1-\chi}{\chi} r$$

- $\bar{\ell} = 0$: A no-banking equilibrium

$$\ell = \bar{\ell} = \frac{1-\chi}{\chi} r = 0$$

Comparative statics

	scarce-reserve $\ell^* \geq \bar{\ell} > 0$		ample-reserve $\bar{\ell} > \ell^* \geq 0$		no-banking $\bar{\ell} = 0$		
ζ	$\frac{\partial r}{\partial \zeta}$	$\frac{\partial i_d}{\partial \zeta}$	$\frac{\partial r}{\partial \zeta}$	$\frac{\partial i_d}{\partial \zeta}$	$\frac{\partial r}{\partial \zeta}$	$\frac{\partial i_d}{\partial \zeta}$	$\frac{\partial \ell^*}{\partial \zeta}$
i	-	$+$	-	0	0	0	$+$
i_r	$+$	$+$	$+$	$+$	0	0	-

Result

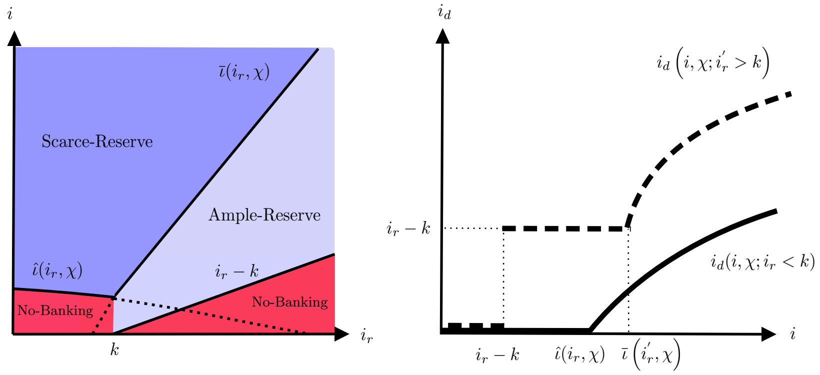


Figure 1: Equilibria and Deposit Rates

Result

Proposition

For given $(i_r, \chi, \bar{\delta})$:

(*i*) $\exists!$ *scarce-reserves equilibrium iff* $i \geq \max\{\hat{\iota}, \bar{\iota}\}$;

(*ii*) $\exists!$ *ample-reserves equilibrium iff* $i \in (0, \bar{\iota})$ *and* $i_r \geq k$;

(*iii*) $\exists!$ *no banking equilibrium either* $i \in [0, \hat{\iota})$ *where* $i_r < k$, *or* $i \in [0, i_r - k)$;

Proposition

$\bar{\iota}$ *is increasing in* i_r, *and* $\hat{\iota}$ *is decreasing in* i_r.

From scarce-reserve to ample-reserve

- constraint matters: $\ell = \min\{\bar{\ell}, \ell^*\}$
  - ℓ^* is increasing in i and decreasing in i_r.
  - $\bar{\ell} = \frac{1-\chi}{\chi} r$ is decreasing in i and increasing in i_r.

- consider the case that the central bank lowers the nominal interest rate from $i > max\{\hat{\iota}, \bar{\iota}\}$ to $i' < \bar{\iota}$ with $i_r > k$.
  - from scarce-reserves to the ample-reserves.
    $\Rightarrow$ decrease in money multiplier
  - huge increase in reserves

Role of credit condition

	scarce-reserve $\ell^* \geq \bar{\ell} > 0$		ample-reserve $\bar{\ell} > \ell^* \geq 0$		no-banking $\bar{\ell} = 0$
	$\bar{\delta} < \hat{\delta}$	$\bar{\delta} > \hat{\delta}$	$\bar{\delta} < \tilde{\delta}$	$\bar{\delta} > \tilde{\delta}$	
$\partial r / \partial \bar{\delta}$	-	0	-	0	0
$\partial i_d / \partial \bar{\delta}$	$+$	0	0	0	0
$\partial \ell^* / \partial \bar{\delta}$	0	0	0	0	0

Role of credit condition

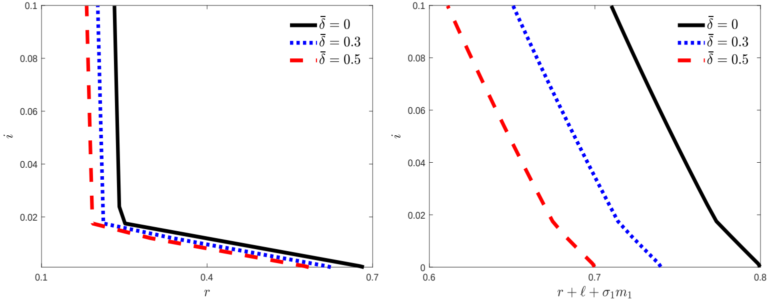


Figure 2: Demand for reserves and the monetary aggregate with different credit limits

Changes in credit access

	scarce-reserve		ample-reserve		no-banking		
	$\ell^* \geq \bar{\ell} > 0$		$\bar{\ell} > \ell^* \geq 0$		$\bar{\ell} = 0$		
	$\frac{\partial r}{\partial \sigma_3}$	$\frac{\partial i_d}{\partial \sigma_3}$	$\frac{\partial r}{\partial \sigma_3}$	$\frac{\partial i_d}{\partial \sigma_3}$	$\frac{\partial r}{\partial \sigma_3}$	$\frac{\partial i_d}{\partial \sigma_3}$	$\frac{\partial \ell^*}{\partial \sigma_3}$
	-	$+$	-	0	0	0	0

Quantitative Analysis

Parameterization

- The utility functions for DM and CM are $u(q) = Aq^{1-\gamma}/(1-\gamma)$ and $U(X) = \log(X)$
- Cost function for DM is $c(q) = q$.
- In the model, the equilibrium is characterized by three policy variables (i, i_r, χ) and credit limit, $\bar{\delta}$.
- $\frac{\sigma_3 \bar{\delta}}{1+\sigma_1 v(q_1)+\sigma_2 v(q_2)+\sigma_3 v(q_3)} = \frac{\text{Unsecured Credit}}{\text{GDP}} \Rightarrow \bar{\delta}$
- Model generates equilibrium by using $(i, i_r, \chi, \frac{\text{Unsecured Credit}}{\text{GDP}})$
- Calibration is based on 1968-2007. Compare in-sample fit (1968-2007) and out-of-sample fit (2008-2017)

Sensitivity analysis for measure of monetary policy

Parameterization

Table 1: Model parametrization

Parameter	Value	Target/source	Data	Model
External Parameters				
enforcement cost curvature, α	2	Set directly		
DM3 matching prob, σ_3	0.4783	Durkin (2000)		
Jointly Determined Parameters				
bargaining Power, θ	0.454	avg. retail markup	1.384	1.384
enforcement cost level, ν	0.020	avg. UC/DM	0.387	0.378
DM1 matching prob, σ_1	0.189	avg. C/D	0.529	0.564
deposit operating cost, k	0.002	avg. R/Y	0.016	0.016
DM utility level, A	0.618	avg. C/Y	0.044	0.044
DM utility curvature, γ	0.398	semi-elasticity of C/Y to i	-3.716	-3.724

Note: C, R, DM, UC, Y denote currency in circulation, reserves, DM transactions, unsecured credit and nominal GDP, respectively. D denotes inside money.

Fitted money demand for currency | Sensitivity analysis for α and σ_3

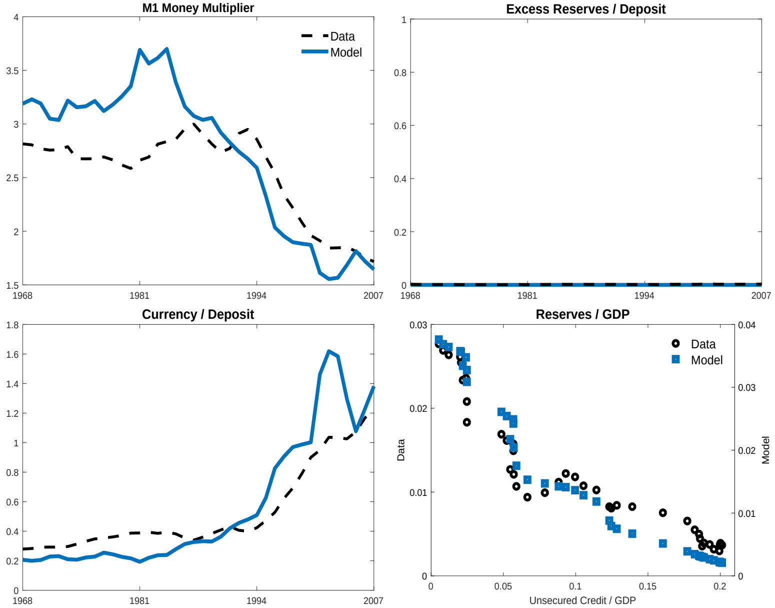


Figure 3: In-sample Fit: 1968-2007

Model-implied regression

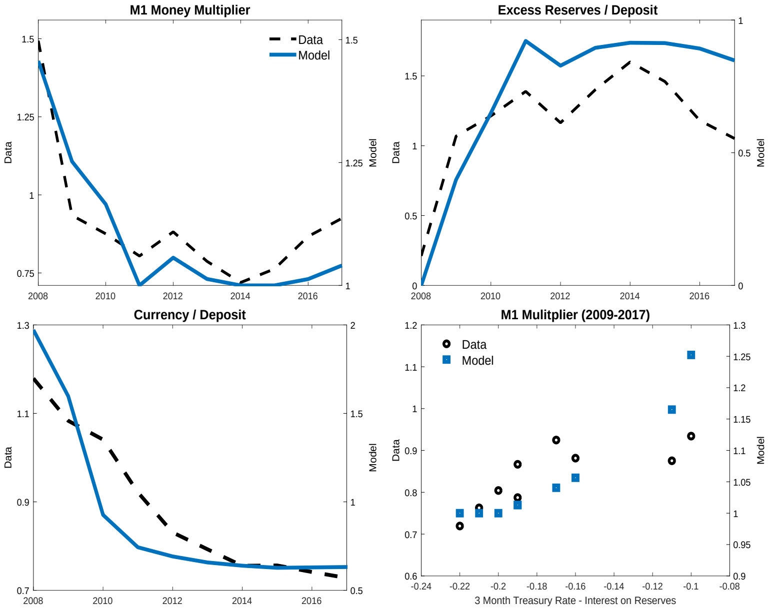


Figure 4: Out-of-sample Fit: 2008-2018

Model-implied regression | Welfare analysis | Counterfactual analysis

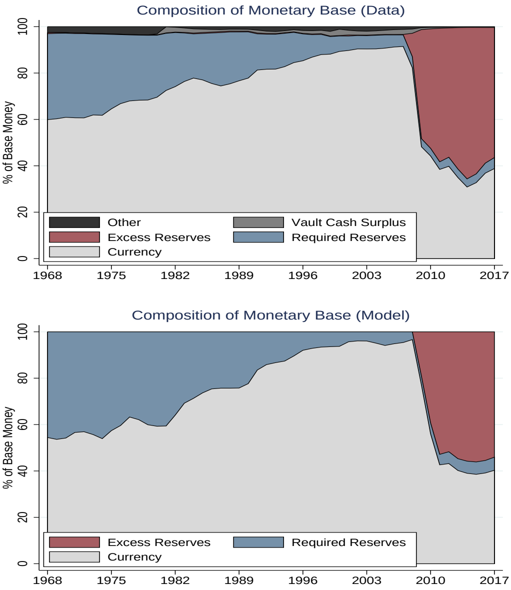


Figure 5: Composition of Monetary Base: Data vs. Model

Conclusion

- I construct monetary-search model of banking to investigate the money creation process.
- Use of unsecured credit crowds out inside money.
- When the central bank pay interest on reserves , money creation is not constrained by reserve requirements but still depends on the nominal interest rates and interests on reserves.
- Quantitatively, the calibrated model can account for the behavior of money creation.

Thank You!

Appendix

Chow test

$$
\begin{aligned}
\text{Money multiplier}_t =& \beta_0 + \beta_1(\text{RequiredReserves/Deposit})_t \\
&+ \mathbf{1}_{t \geq 1992Q2}[\gamma_0 + \gamma_1(\text{RequiredReserves/Deposit})_t] \\
&+ \mathbf{1}_{t \geq 2008Q4}[\delta_0 + \delta_1(\text{RequiredReserves/Deposit})_t] + \epsilon_t
\end{aligned}
$$

F-statistics are obtained by testing $\gamma_0 = \gamma_1 = \delta_0 = \delta_1 = 0$.

$$
\begin{aligned}
\text{Money multiplier}_t =& \beta_0 + \beta_1(\text{Currency/Deposit})_t \\
&+ \mathbf{1}_{t \geq 2008Q4}[\delta_0 + \delta_1(\text{Currency/Deposit})_t] + \epsilon_t
\end{aligned}
$$

F-statistics are obtained by testing $\delta_0 = \delta_1 = 0$. Back to motivation

Chow test for structural breaks

Table 2: Require Reserve Ratio

Dependent Variable: Money Multiplier	
RR	-0.601
	(0.365)
RR $\times$ $\mathbf{1}_{t\geq 1992Q2}$	132.279***
	(0.031)
RR $\times$ $\mathbf{1}_{t\geq 2008Q4}$	-147.943***
	(8.574)
$\mathbf{1}_{t\geq 1992Q2}$	9.091***
	(0.557)
$\mathbf{1}_{t\geq 2008Q4}$	0.074***
	(0.611)
Constant	2.813***
	(0.053)
Obs.	228
R^2	0.963
DF for numerator	4
DF for denominator	222
F Statistic for Chow test	1711.32
F Statistic for 1% sig. level	3.40
F Statistic for 0.1% sig. level	4.79

Back to motivation

Chow test for structural breaks

Table 3: Currency Deposit Ratio

Dependent Variable: Money Multiplier	
CD	-1.301***
	(0.027)
CD $\times$ $\mathbf{1}_{t \geq 2008Q4}$	-52.018***
	(4.995)
$\mathbf{1}_{t \geq 2008Q4}$	3.061***
	(0.409)
Constant	3.159***
	(0.015)
Obs.	228
R^2	0.974
DF for numerator	2
DF for denominator	224
F Statistic for Chow test	1245.69
F Statistic for 1% sig. level	4.70
F Statistic for 0.1% sig. level	7.13

Back to motivation

Fitted money demand for currency

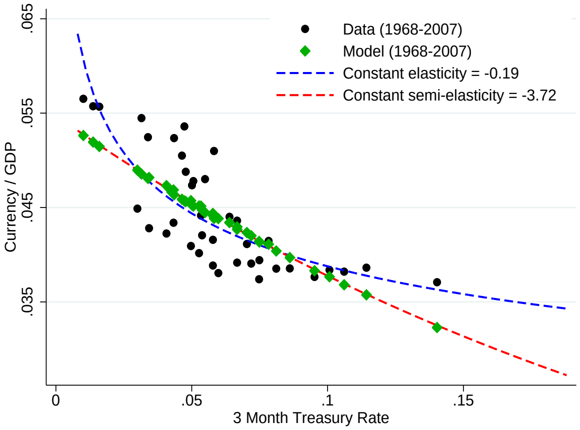


Figure 6: Money demand for currency

Model parametrization

Model-implied regression

Table 4: Model-implied regression coefficients, model vs. data

Dependent Variable:	Reserves/GDP (1968-2007)		M1 Money Multiplier (2009-2017)		Excess Reserve/Deposit (2009-2017)	
	Data (1)	Model (2)	Data (3)	Model (4)	Data (5)	Model (6)
Unsecured Credit/GDP	-0.123***	-0.190				
	(0.004)					
3 Month T-bill Rate	-0.083***	-0.072	1.004***	1.999	-2.447***	-3.771
	(0.011)		(0.156)		(0.423)	
Interest on Reserves			-0.892***	-2.034	2.137***	3.842
			(0.150)		(0.405)	
R^2	0.876	0.849	0.652	0.922	0.612	0.855

Notes: Columns (1)-(2) report the canonical cointegrating regression (CCR) estimates. First stage long-run variance estimation for CCR is based on Bartlett kernel and lag 1. Columns (3)-(6) report OLS estimates. For (3) and (5) Newey-West standard errors with lag 1 are reported in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Intercepts are included but not reported.

In-sample fit Out-of-sample fit

Welfare

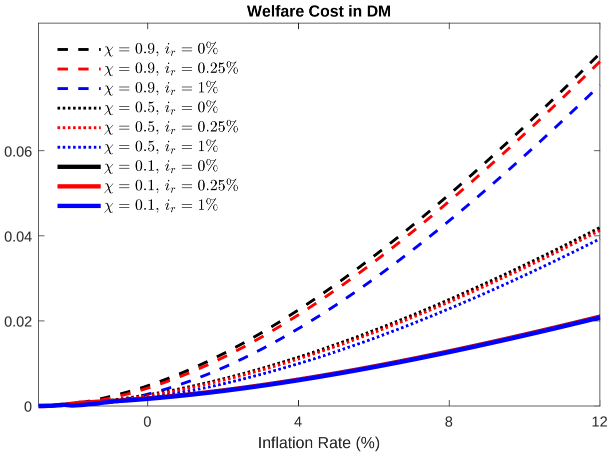


Figure 7: Cost of inflation

Out-of-sample fit

Welfare

	$i_r = 0\%$ $\chi = 0.1$ (1)	$i_r = 0.25\%$ $\chi = 0.1$ (2)	$i_r = 0\%$ $\chi = 0.5$ (3)	$i_r = 0.25\%$ $\chi = 0.5$ (4)	$i_r = 0\%$ $\chi = 0.9$ (5)	$i_r = 0.25\%$ $\chi = 0.9$ (6)
q_1	0.141	0.141	0.141	0.141	0.141	0.141
$q_2 = q_3$	0.263	0.263	0.204	0.206	0.152	0.154
$1 - \Delta$	0.0167	0.0167	0.0331	0.0324	0.0655	0.0638

Out-of-sample fit

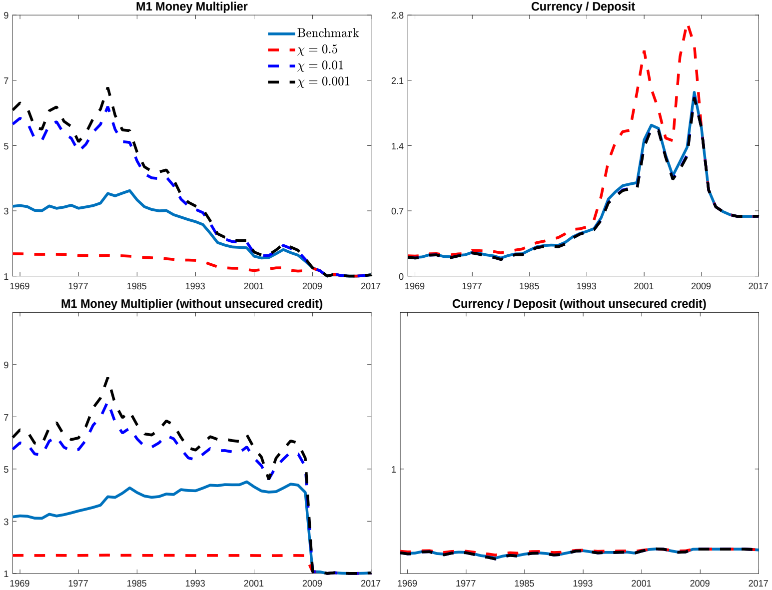


Figure 8: Counterfactual analysis

Out-of-sample fit

Sensitivity analysis

Table 5: Alternative parametrizations

	Data	Baseline	Model 1	Model 2	Model 3	Model 4	M2
External Parameters							
α		2	1.8	2.2	1.8	2.2	2
σ_3		0.4783	0.3	0.3	0.4783	0.4783	0.4783
Calibration targets							
avg. retail markup	1.384	1.384	1.386	1.383	1.384	1.383	1.387
avg. C/Y	0.044	0.044	0.044	0.044	0.044	0.044	0.044
avg. R/Y	0.016	0.016	0.016	0.016	0.016	0.016	0.011
semi-elasticity of C/Y	-3.716	-3.724	-3.720	-3.729	-3.724	-3.729	-3.019
avg. C/D	0.529	0.564	0.574	0.557	0.564	0.557	
avg. UC/DM	0.387	0.378	0.379	0.377	0.378	0.377	
avg. C/D (M2)	0.090						0.103
avg. UC/DM (M2)	0.159						0.175

Note: C, R, DM, UC, Y denote currency in circulation, reserves, DM transactions, unsecured credit and nominal GDP, respectively.

Model parametrization

Sensitivity analysis

Table 6: Alternative parametrizations

	Data	Baseline	Model 1	Model 2	Model 3	Model 4	M2
External Parameters							
α		2	1.8	2.2	1.8	2.2	2
σ_3		0.4783	0.3	0.3	0.4783	0.4783	0.4783
Calibration targets							
avg. retail markup	1.384	1.384	1.386	1.383	1.384	1.383	1.387
avg. C/Y	0.044	0.044	0.044	0.044	0.044	0.044	0.044
avg. R/Y	0.016	0.016	0.016	0.016	0.016	0.016	0.011
semi-elasticity of C/Y	-3.716	-3.724	-3.720	-3.729	-3.724	-3.729	-3.019
avg. C/D	0.529	0.564	0.574	0.557	0.564	0.557	
avg. UC/DM	0.387	0.378	0.379	0.377	0.378	0.377	
avg. C/D (M2)	0.090						0.103
avg. UC/DM (M2)	0.159						0.175

Note: C, R, DM, UC, Y denote currency in circulation, reserves, DM transactions, unsecured credit and nominal GDP, respectively.

Model parametrization

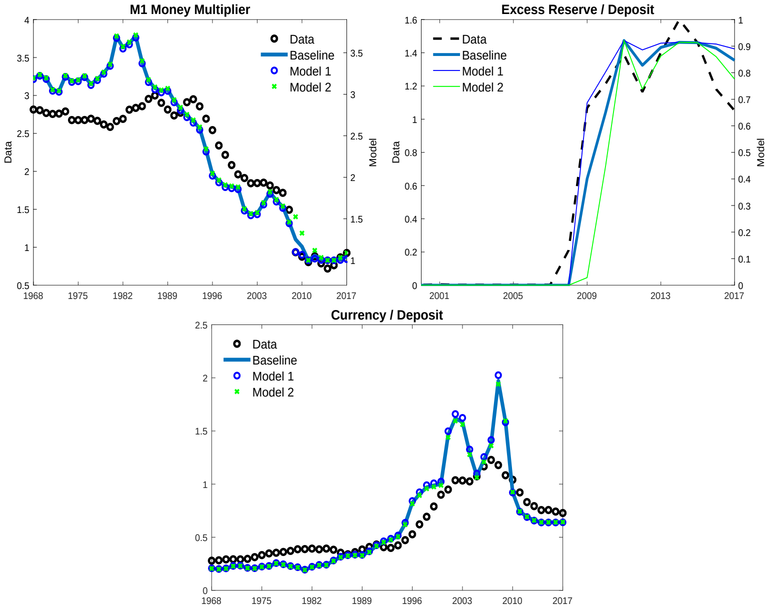
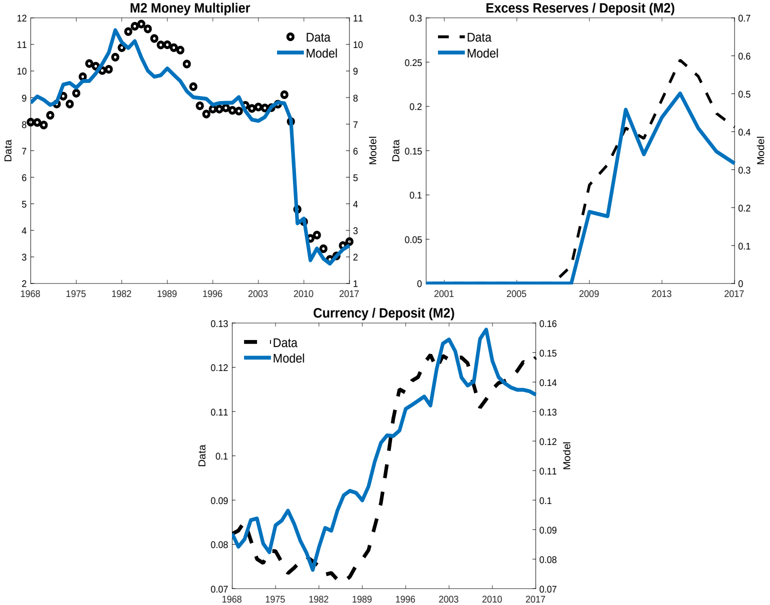


Figure 9: Model Fit with Different Specifications

Model parametrization


M2 Money Multiplier
Data
Model
Excess Reserves / Deposit (M2)
Data
Model
Currency / Deposit (M2)
Data
Model
1968
1975
1982
1989
1996
2003
2010
2017
2001
2005
2009
2013

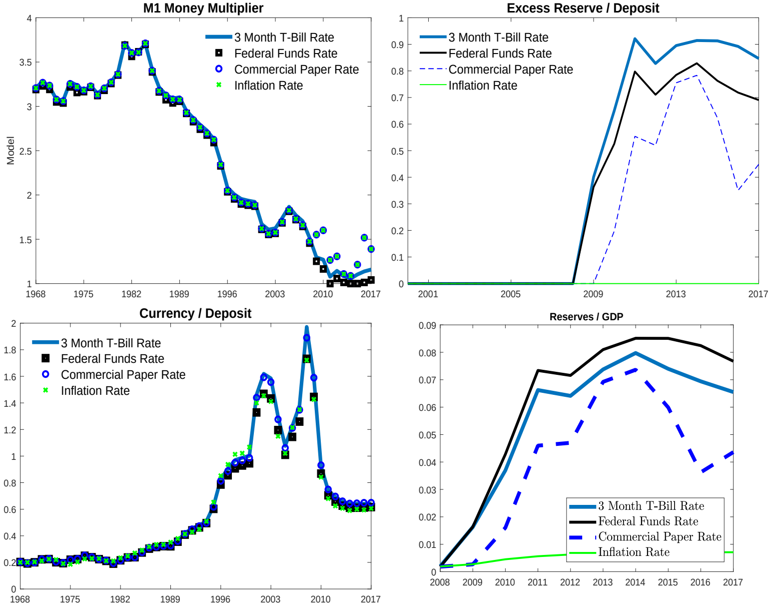


Figure 10: Model fit with measure of monetary policy

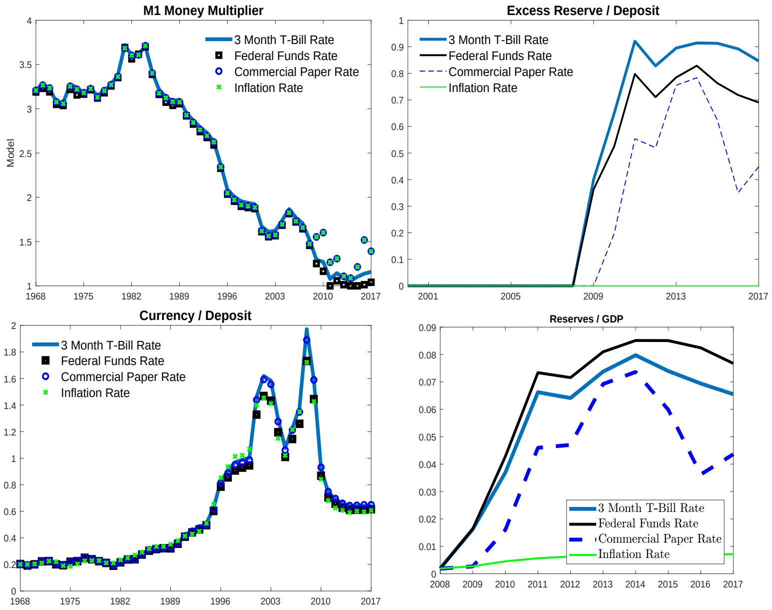


Figure 11: Model fit with measure of monetary policy

Sensitivity analysis

Table 7: Parametrizations with different measure of monetary policy

Interest/Inflation rate	3 Month T-bill		Federal Funds		CP		Core PCE	
	Data	Model	Data	Model	Data	Model	Data	Model
Targets								
avg. retail markup	1.384	1.384	1.384	1.384	1.384	1.384	1.384	1.384
avg. C/Y	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
avg. R/Y	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
avg. C/D	0.529	0.564	0.529	0.531	0.529	0.554	0.529	0.551
avg. UC/DM	0.387	0.378	0.387	0.373	0.387	0.376	0.387	0.375
semi-elasticity of C/Y	-3.716	-3.724	-3.020	-3.012	-3.454	-3.440	-4.258	-4.220
Parameter								
bargaining power, θ		0.454		0.512		0.476		0.423
enforcement cost level, ν		0.020		0.019		0.016		0.016
DM1 matching prob, σ_1		0.189		0.184		0.189		0.201
deposit operating cost, k		0.002		0.002		0.002		0.002
DM utility level, A		0.618		0.598		0.611		0.642
DM utility curvature, γ		0.398		0.427		0.408		0.378

Note: C, R, DM, UC, Y denote currency in circulation, reserves, DM transactions, unsecured credit and nominal GDP, respectively.

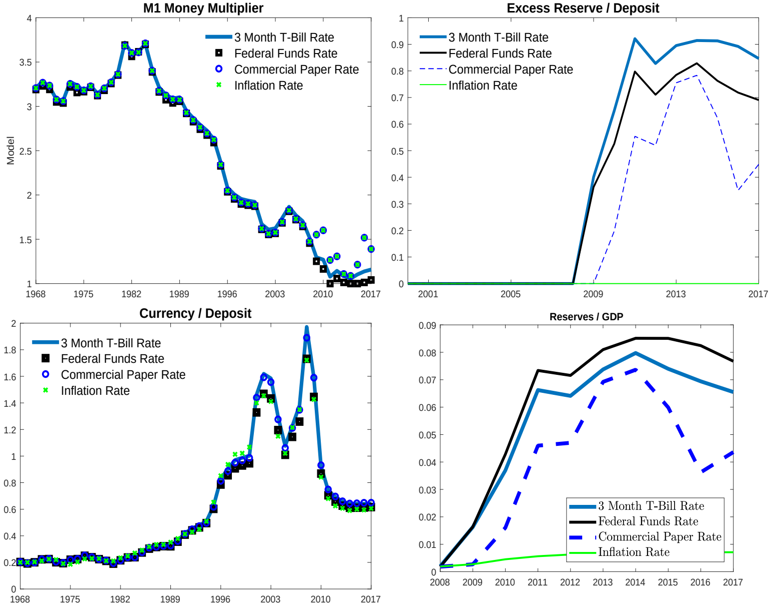


Figure 12: Model fit with measure of monetary policy

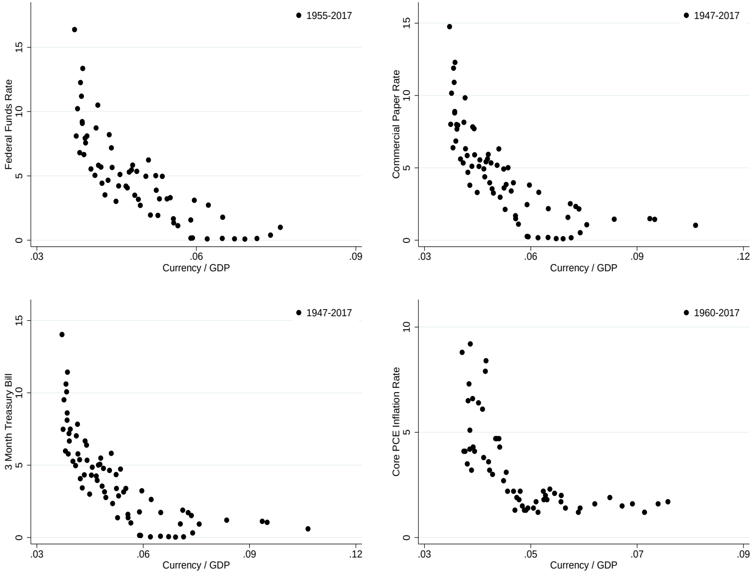


Figure 13: Money demand for currency

back to increase of currency

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