The collateral channel of unconventional monetary policy operations

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The views are those of the authors and do not necessarily represent the views of the Bank of Italy

Motivation

- Financial assets are held for two motives:
  - investment
  - to use as **collateral in money lending markets**
- Since the beginning of the financial crisis, volume of collateralized interbank transactions increased
- Open Market Operations by the Central bank alter the **relative availability** in the economy of collateral and money
- **Is there an effect on the price of financial assets used as collateral?**

This paper

- General Equilibrium model in which **trading frictions require the use of money**
- **Financial assets** have the property of **facilitating exchanges**:
  - Directly in exchanges btw households: collateralized credit
  - In interbank collateralized transactions for liquidity
- Two assets, with **different pledgeability properties (haircuts)**
- In this framework, **scarcity of collateral determines a liquidity premium** in the price of assets, different according to haircuts levels
- **The Central bank**, through OMO, **influences the liquidity premium** of assets

This paper

- Take the implications of the model to the data
- **Panel dataset of yields of euro area sovereigns** of different maturities from June 2009 to December 2014
- Consistently with model predictions, we find:
  - **Negative relation between yields and relative scarcity of collateral**
  - **Magnitude of relation is different depending on asset's haircut levels**
- Issues:
  - Endogeneity
  - Collateral channel or something else?

Related Literature

- We combine three features:
  - Assets as a medium-of-exchange (Lagos and Wright, 2005).
  - General equilibrium effects of monetary policy with banks á la Diamond and Dybvig (Williamson, 2012).
  - Role of interbank markets in presence of idiosyncratic liquidity shocks (Bhattacharya and Gale, 1986; Allen, Carletti and Gale, 2009; Heider and Hoerova, 2009; Freixas, Martin and Skeie, 2011).
- Related contributions
  - Preferred-habitat contributions: Vayanos-Vila (2009), Greenwood-Vayanos (2013)
  - Empirical estimates of the effects of QE: Gagnon et al. (2011), Krishnamurty and Vissing-Jorgensen (2011), D'Amico and King (2013) ...
  - Effects on repo markets of OMO: Corradin-Maddaloni (2015), Boissel et al. (2014)
  - Collateral channel of LSAP: D'Amico, Fan and Kitsul (2014)

Bird's eye view of the model - I

- Trade is quid pro quo. **Buyers** and **Sellers** settle their **exchanges with money or credit claims** issued by banks and backed by assets (a nominal bond and a real asset)
- Fiat money is dominated in rate of return by the other assets. However **only a fraction of Sellers accept credit claims**. Buyers **do not know** which Sellers will meet when choosing portfolio.
- As in Diamond and Dybvig **banks diversify**, thus providing insurance to their depositors (Buyers).
  - give money or issue credit claims according to buyers' type of meeting

Bird's eye view of the model - II

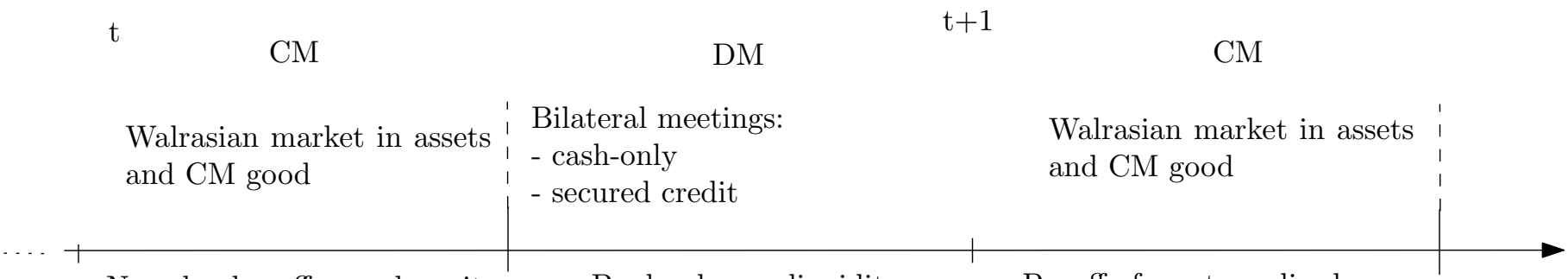
- Banks themselves face **random shocks on the fraction of depositors** that needs to withdraw money: an **interbank market** provides insurance against risk of being unable to satisfy demand of depositors
  - same frictions that operate between buyers and sellers characterize exchanges by banks in interbank market: **collateralized lending**.
  - Nominal bond and real asset differ by their **pledgeability properties (haircuts)**: A unit of real asset can only secure $(1-h)$ units of loans.

$$Rl \leq b + (1-h)a$$

- The **central bank**, through open market operations, **determines the relative amount of fiat money to other assets in the economy**.

$$\delta \equiv \frac{money}{money + assets\ in\ the\ economy}$$

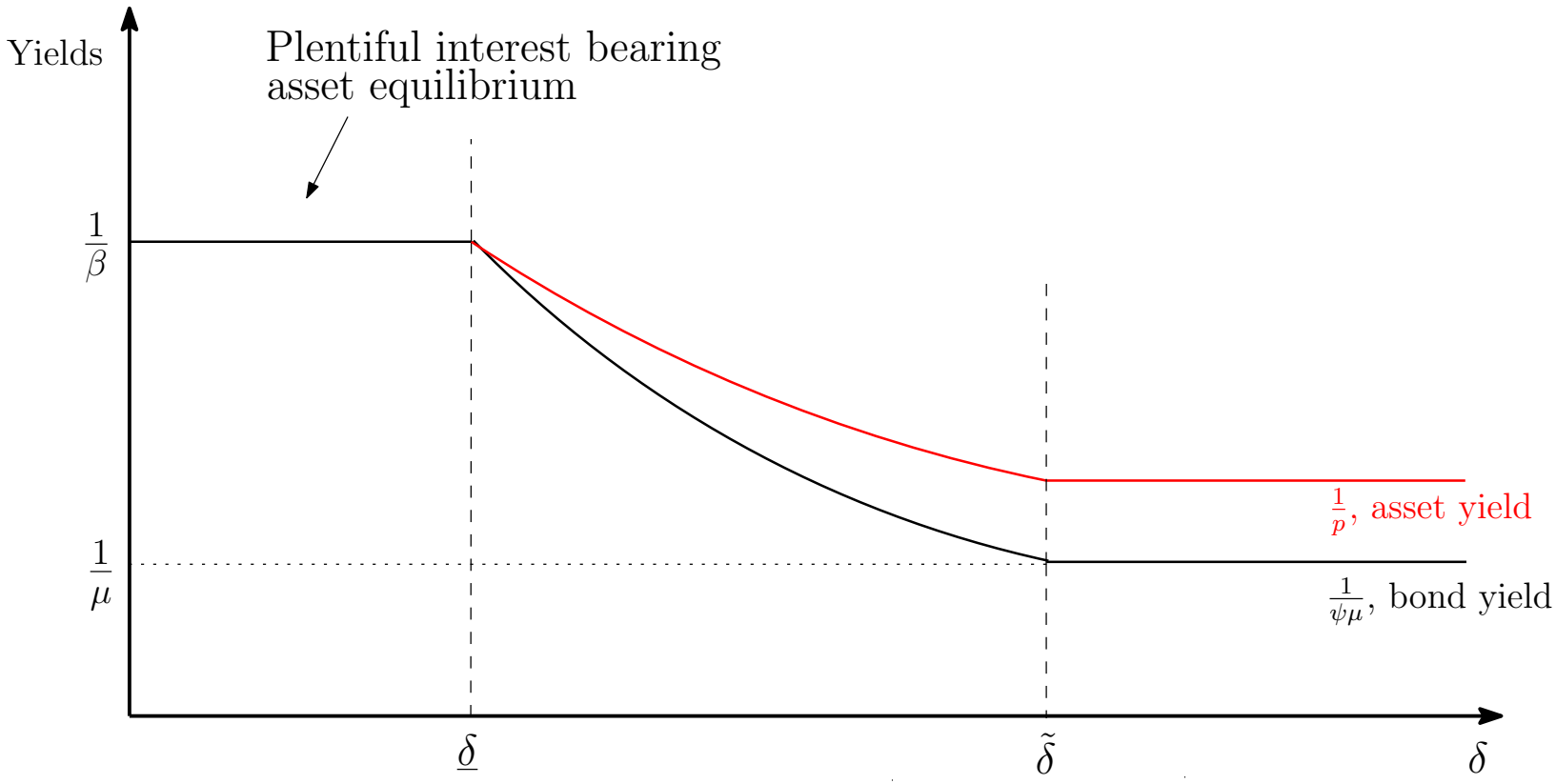
Timeline


t
CM
DM
t+1
CM
Walrasian market in assets and CM good
Bilateral meetings:
- cash-only
- secured credit
Walrasian market in assets and CM good
New banks offer a deposit contract to buyers.
Consumption and production choices of buyers and sellers.
Buyers make deposits and banks make their portfolio choice.
Banks observe liquidity shocks and enter the interbank market.
Buyers withdraw after observing their type of meeting.
Buyers make *take-it-or-leave-it* offer to sellers and consume.
Payoff of assets realized
Banks settle interbank debt and sellers claims.
Banks redistribute any excess resources and dissolve
New banks are born...

Solution approach

- Perfect competition in the banking sector: banks choose portfolio and offer deposit contracts to maximize the welfare of their depositors ▸ Banks problem
- Focus on **stationary equilibria** in which: ▸ Eq. Definition
  - Real quantities and other prices are constant
  - Growth rate of nominal quantities determines the inflation rate: $\mu = \frac{\phi_t}{\phi_{t+1}}$
- **Equilibrium price and quantities only depend on CB choice of δ**
  $\delta \equiv$ *relative amount of money to other assets in the economy*
- **Positive analysis**: focus on the role of δ in equilibrium price determination

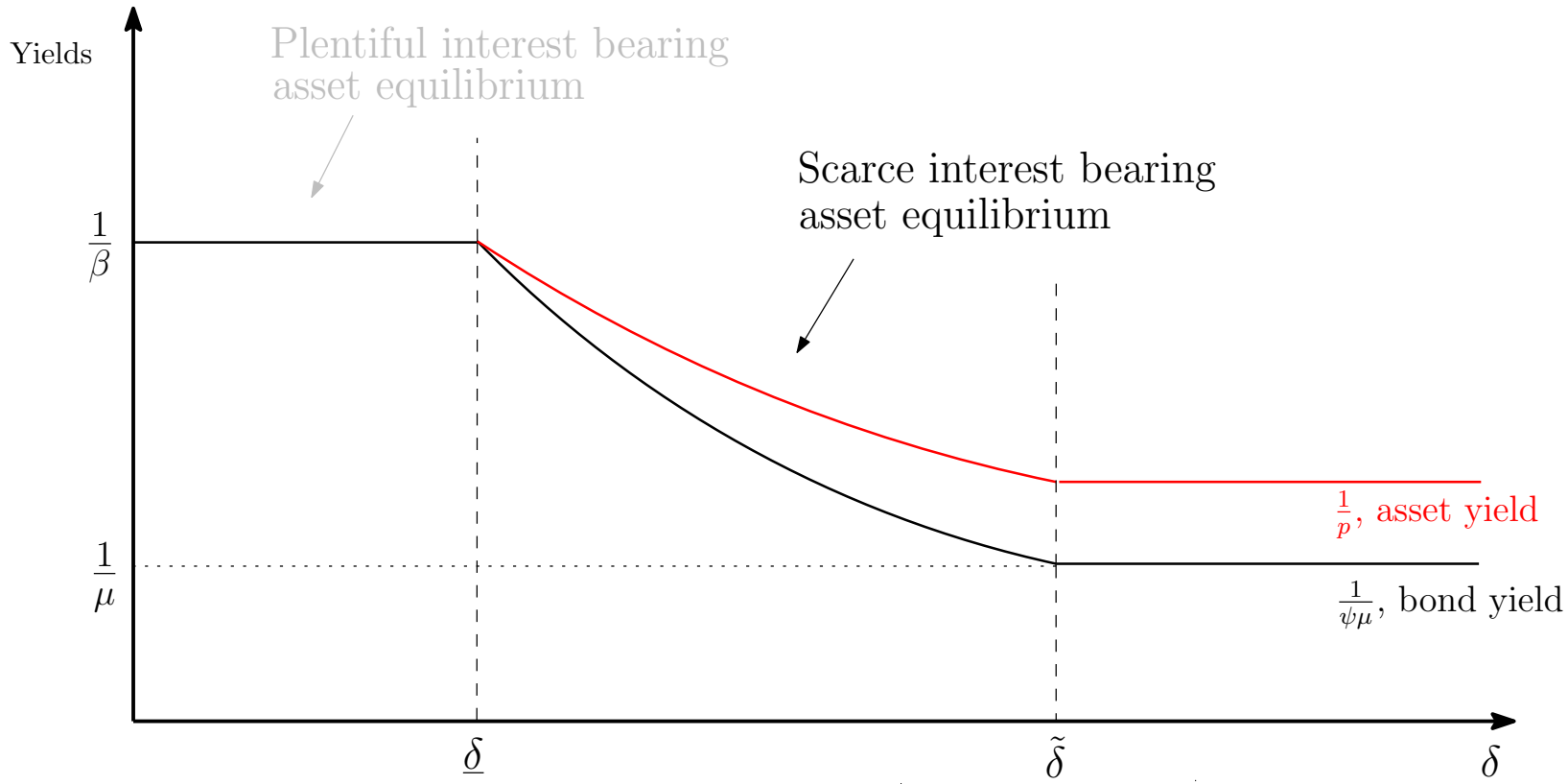
Equilibria



- Price of bond/asset is at fundamental value

▸ Interbank Mk. ▸ Consumption

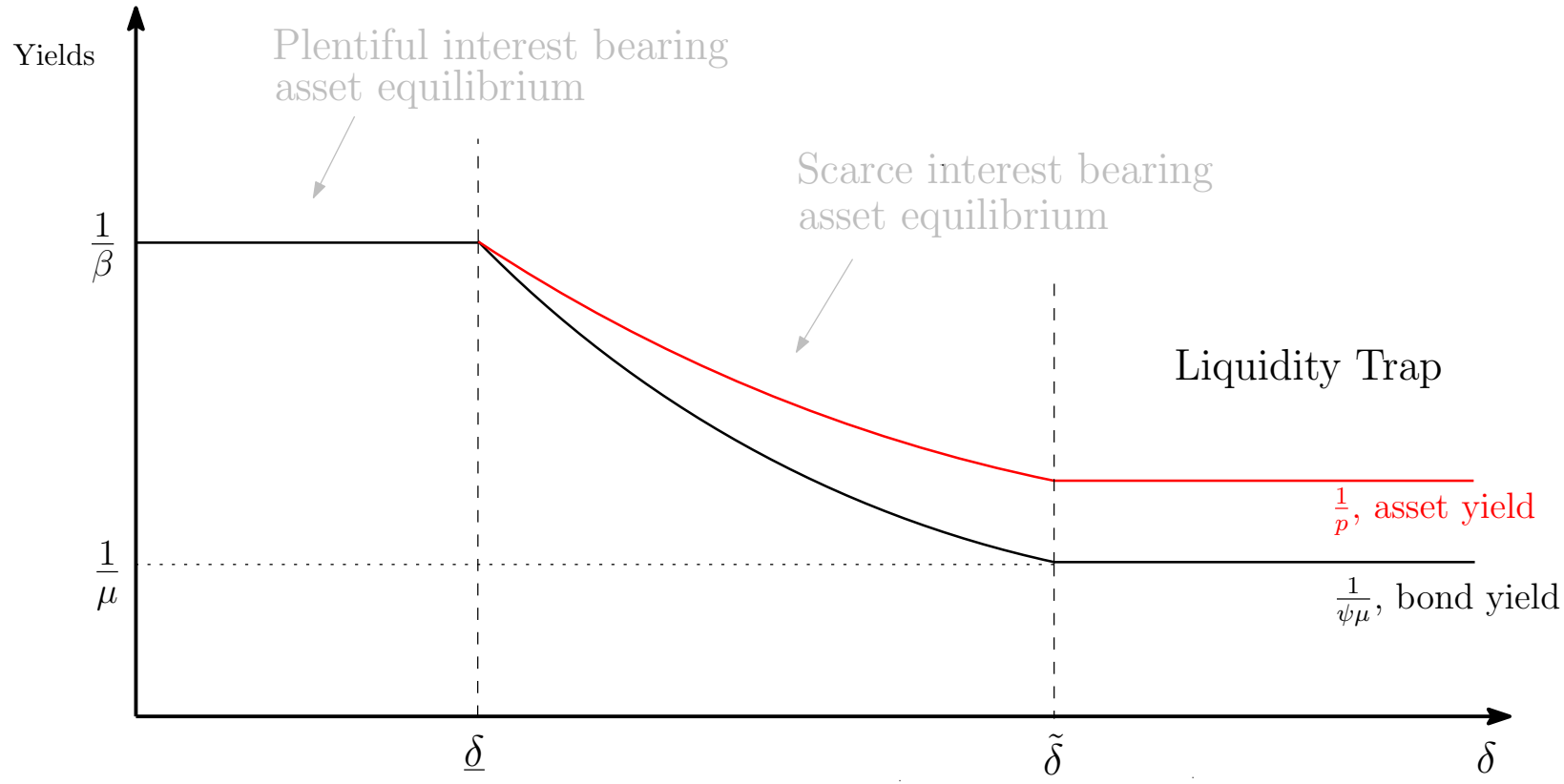
Equilibria



- Scarcity of collateral: price of bond/asset has a **liquidity premium**
- Asset: $p = (1 - h)\psi\mu + h\beta$

▸ Interbank Mk. ▸ Consumption

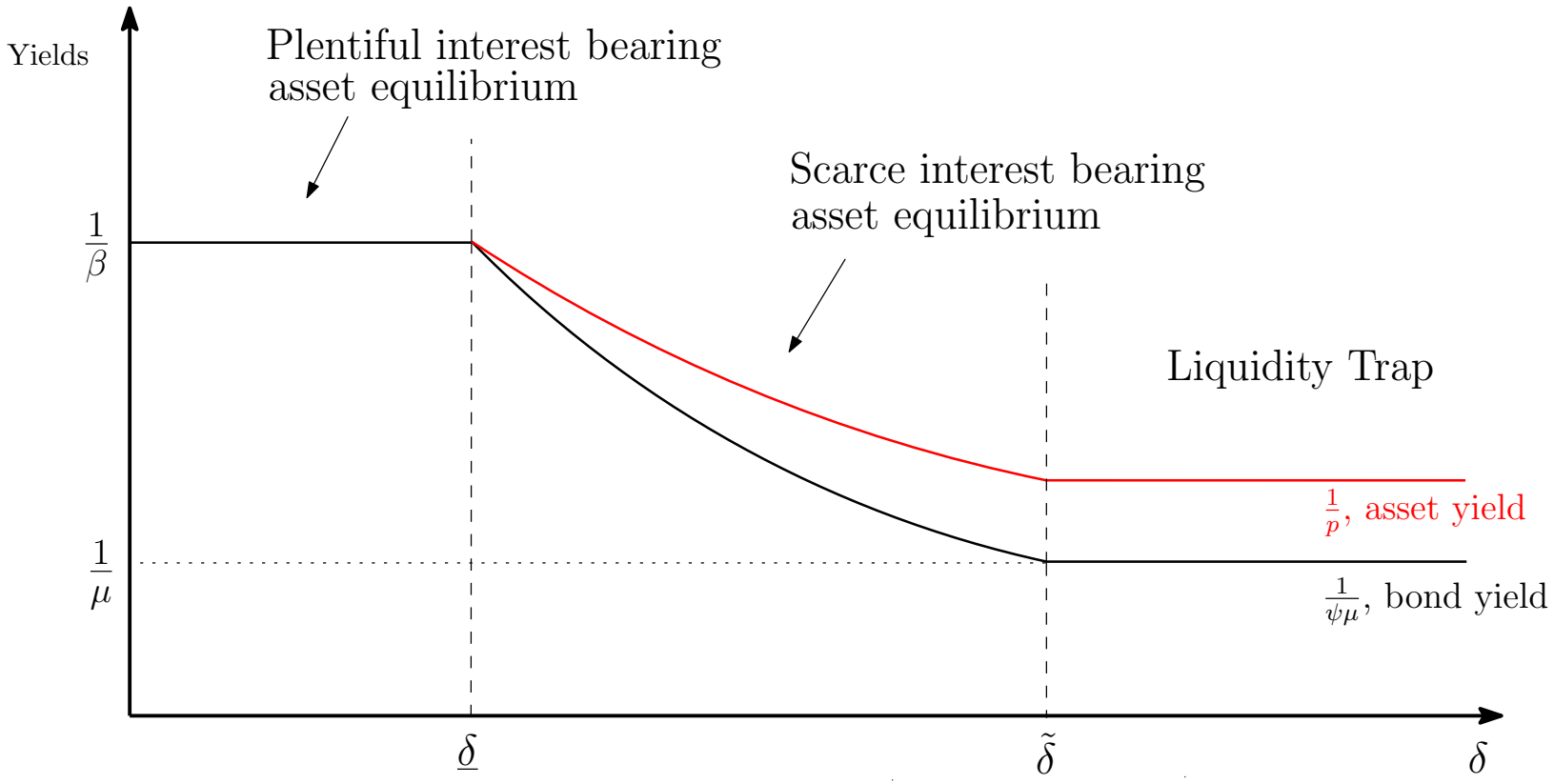
Equilibria



- Return of bond is same as money
- Higher return of asset because of haircut

▸ Interbank Mk. ▸ Consumption

Equilibria



▸ Interbank Mk. ▸ Consumption

Empirical Implications

- Relative availability of money and pledgeable assets in the economy influences price of securities
  - **Yields are weakly decreasing in the amount of relative liquidity**
  - Magnitude of **effect is different according to haircut** of the securities
- Securites with **higher haircuts have higher yields**

Dataset

- Panel datasets of yields on euro area sovereigns from June 2009 to December 2014 at 2,3,4,7,10,15,30 year maturity
- Austria, Belgium, France, Germany, Ireland, Italy, Netherlands, Spain
- Haircuts levels applied on repo market from a large Central Clearing Counterparty (Cassa di Compensazione e Garanzia)
- Empirical counterpart of $\delta = \frac{(1)}{(1)+(2)}$:
  - (1) Reserves of euro area banks held in the Current account and Deposit facility
  - (2) Euro area sovereigns held by banks on their balance sheet
- Price of Credit Default Swaps contracts with same maturity as sovereigns
- Rate on Interest Rate Swaps contracts with same maturity of sovereigns
- Monthly frequency (end of month)

Empirical strategy

Object of analysis: *basis*

$$b_{c,i,t} \equiv (y_{c,i,t} - IRS_{i,t}) - CDS_{c,i,t}$$

Estimate equation of the form:

$$b_{c,i,t} = \beta_0 + \beta_1 \delta_t + \beta_2 h_{c,i,t} + \beta_3 \delta_t * h_{c,i,t} + \boldsymbol{\mu}' \mathbf{X}_{c,i,t} + \varepsilon_{c,i,t}$$

where c stands for country and i for sovereign maturity

▸ Relative liquidity

Baseline estimates

	Pooled OLS (1)	Panel FE (2)
δ	-4.058***	-3.847***
	(1.035)	(0.959)
Haircut	-1.532*	-2.320***
	(0.789)	(0.461)
δ*Haircut	16.80***	15.50***
	(2.132)	(0.725)
Country FE	Y	
Maturity FE	Y	
Quarter-Year FE	Y	Y
Observations	1505	1505
R-squared	0.759	0.475
Marginal effects		
δ (haircut= 1%)	-3.890***	-3.692***
	(1.030)	(0.958)
δ (haircut= 4%)	-3.387**	-3.227**
	(1.017)	(0.955)
δ (haircut= 10%)	-2.379**	-2.297**
	(1.003)	(0.949)
Haircut (at 50p of δ)	1.218**	0.217
	(0.496)	(0.412)

Robust and clustered by country standard errors in parentheses. Significance values based on small sample statistics; *** p<0.01, ** p<0.05, * p<0.1.

Economic significance

- Relative liquidity
  - Suppose δ **increases by 0.01**
    ($\Longrightarrow$ increase in reserves of 25 billions (7%) w.r.t Dec 2014 values)
  - Yields of assets with 10% haircut decreases by **around 2 basis points**
- Haircut
  - Suppose a **haircut increase of 1%**
  - Yields of asset increase by **1 basis points** (w.r.t level of δ in Dec 2014)

Robustness checks

- Reserves and sovereigns held by banks might be endogenous to price developments
  - **Fear of crises**: Reserves injections to quell fears
  - **Carry trade**: borrow cheaply and buy sovereigns
- Stationarity issues
- Haircuts might be **linked to confidence crisis**

Robustness checks

- Reserves and sovereigns held by banks might be endogenous to price developments
  - **Fear of crises**: Reserves injections to quell fears - **restrict sample**
  - **Carry trade**: borrow cheaply and buy sovereigns - **split Core/Non-core**
- Stationarity issues - **lag dep. var./regression in first difference**
- Haircuts might be **linked to confidence crisis** - **instrument**

Robustness: crisis

	Pooled OLS	Panel FE
	(1)	(4)
	Restriced	Restricted
δ	-4.417***	-3.125***
	(1.166)	(0.782)
Haircut	-4.071**	-3.849***
	(1.336)	(0.447)
δ*Haircut	35.76***	23.64***
	(7.100)	(5.145)
Country FE	Y	
Maturity FE	Y	
Quarter-Year FE	Y	Y
Observations	980	980
R-squared	0.742	0.504
Marginal effects		
δ (haircut= 1%)	-4.059***	-2.888***
	(1.126)	(0.768)
δ (haircut= 4%)	-2.986**	-2.179**
	(1.026)	(0.745)
δ (haircut= 10%)	-0.841	-0.760
	(0.946)	(0.795)
Haircut (at 50p of δ)	1.783***	0.0208
	(0.476)	(0.622)

Robust and clustered by country standard errors in parentheses. Significance values based on small sample statistics; *** p<0.01, ** p<0.05, * p<0.1.

Restricted excludes June 2011 till June 2013. Core countries: Austria, Belgium, France, Germany, Netherlands. Non-core countries: Ireland, Italy, Spain.

Robustness: crisis

	Pooled OLS			Panel FE		
	(1) Restriced	(2) Core	(3) Non-core	(4) Restricted	(5) Core	(6) Non-core
δ	-4.417***	-2.684**	-5.118**	-3.125***	-2.458**	-4.733**
	(1.166)	(0.699)	(0.629)	(0.782)	(0.691)	(1.000)
Haircut	-4.071**	-1.375**	-2.818	-3.849***	-1.305***	-2.599***
	(1.336)	(0.306)	(1.179)	(0.447)	(0.259)	(0.134)
δ*Haircut	35.76***	14.42**	12.00	23.64***	12.45**	9.618***
	(7.100)	(4.744)	(4.522)	(5.145)	(3.995)	(0.274)
Country FE	Y	Y	Y			
Maturity FE	Y	Y	Y			
Quarter-Year FE	Y	Y	Y	Y	Y	Y
Observations	980	959	546	980	959	546
R-squared	0.742	0.806	0.751	0.504	0.752	0.595
Marginal effects						
δ (haircut= 1%)	-4.059***	-2.540**	-4.998**	-2.888***	-2.333**	-4.637**
	(1.126)	(0.658)	(0.634)	(0.768)	(0.654)	(0.998)
δ (haircut= 4%)	-2.986**	-2.107**	-4.638**	-2.179**	-1.960**	-4.349**
	(1.026)	(0.540)	(0.666)	(0.745)	(0.547)	(0.990)
δ (haircut= 10%)	-0.841	-1.242**	-3.918**	-0.760	-1.212**	-3.772*
	(0.946)	(0.362)	(0.800)	(0.795)	(0.360)	(0.974)
Haircut (at 50p of δ)	1.783***	0.986	-0.855	0.0208	0.733	-1.024**
	(0.476)	(0.531)	(0.568)	(0.622)	(0.520)	(0.179)

Robust and clustered by country standard errors in parentheses. Significance values based on small sample statistics; *** p<0.01, ** p<0.05, * p<0.1.

Restricted excludes June 2011 till June 2013. Core countries: Austria, Belgium, France, Germany, Netherlands. Non-core countries: Ireland, Italy, Spain.

Robustness: Stationarity

	OLS
δ	-2.918**
	(1.000)
Haircut	-0.530
	(0.287)
δ*Haircut	4.094***
	(1.168)
Basis_{t-1}	0.708***
	(0.0551)
Country FE	Y
Maturity FE	Y
Quarter-Year FE	Y
Observations	1505
R-squared	0.885
Marginal effects	
δ (haircut= 1%)	-2.877**
	(0.992)
δ (haircut= 4%)	-2.754**
	(0.967)
δ (haircut= 10%)	-2.508**
	(0.919)
Haircut (at 50p of δ)	0.140
	(0.151)

Robust and clustered by country standard errors in parentheses. Significance values based on small sample statistics; *** p<0.01, ** p<0.05, * p<0.1.

Robustness: IV

	IV	IV
δ	-2.687**	-2.593**
	(0.923)	(0.856)
Haircut	15.21***	2.741**
	(3.212)	(1.016)
δ*Haircut	1.188	0.821
	(3.856)	(1.375)
Basis_{t-1}		0.674***
		(0.0501)
R-squared		
Marginal effects		
δ (haircut= 1%)	-2.676**	-2.585**
	(0.930)	(0.860)
δ (haircut= 4%)	-2.640**	-2.560**
	(0.958)	(0.873)
δ (haircut= 10%)	-2.569**	-2.511**
	(1.052)	(0.903)
Haircut (at 50p of δ)	15.41***	2.875**
	(2.765)	(0.869)

Robust and clustered by country standard errors in parentheses. Significance values based on small sample statistics; *** p<0.01, ** p<0.05, * p<0.1. Columns (1) and (2) estimated with 2SLS methods, the variable haircut being instrumented by the lagged value of the sovereign yield. Country, maturity and quarter-year FE included.

Preferred-habitat vs. collateral channel

- Negative correlation: consistent with both a preferred-habitat story and our collateral channel story
- **Effects of haircuts** difficult to reconcile with preferred-habitat behaviour:
  - Greenwood-Vayanos (2013): **scarcity effects are stronger for longer term maturities**
  - In our estimates: **scarcity effects are lower for higher haircuts levels** ($\approx$ longer term maturities)

Conclusion

- Model where assets have a role in facilitating trades
- Liquidity premium arise which depends on haircuts and relative availability of money and collateral
- Empirical analysis on euro area sovereigns consistent with model
- **Policy implications**:
  - Additional channel of APP
  - ECB securites lending and money markets
  - Large CB balance sheet and scarcity of collateral

Framework

- Time is infinite and discrete
  - Two subperiods: **DM** (Decentralized Market) and **CM** (Centralized Market), each with their own perishable good
- Two types of agents, **Buyers** and **Sellers**
  - In the CM: both produce and consume the CM good
  - In the DM: Sellers produce the DM good that Buyers consume. They meet randomly and **trade pairwise**
- Banking sector; Consolidated government
- **Assets**:
  - Fiat money
  - One period nominal bonds
  - One period real asset (positive net supply)
  - **Assets markets are open during the CM only**

Trading friction in the DM

- No record-keeping technology and limited commitment: **trades in the DM are quid pro quo**

- A fraction ρ of Sellers only accepts money: **cash-only meetings**
- The remaining Sellers also accepts credit claims backed by assets: **secured credit meetings**
  - Buyers discover the type of seller only in the DM

- Insurance role of banks as in Diamond-Dybvig. Banks offer **deposit contracts**:
  - In the CM: Collect deposit from Buyers / Buy money and other assets
  - In the DM: Offer withdrawal rights of money or credit claims secured by bank's asset

Collateralised Interbank Market

- Banks face a liquidity shock during the DM (a la Bhattacharya and Gale (1986)): exchange money in **collateralised interbank market**
  - Interbank market is Walrasian
  - Bond and real asset differ by their **pledgeability properties**: only a fraction $(1-h)$ of the real asset value can be pledged on interbank market
- To obtain (real) money l, bank pay a gross rate R and post collateral such that:

$$Rl \leq b + (1-h)a$$

Monetary policy

- Consolidated government **emits money and government bonds** in the CM (fiscal policy is passive)
- Monetary policy choose the couple (μ, δ) where
  - $\mu \equiv \frac{M_t+B_t}{M_{t-1}+B_{t-1}}$: (gross) growth rate of nominal government liabilities
  - $\delta \equiv \frac{M_t}{M_t+B_t}$: relative size of money with respect to bonds.
  - **Change in** δ: **Open Market Operation** altering ratio of money to bonds (**relative liquidity**)
- Monetary policy chooses quantities, not interest rates!

Solution approach

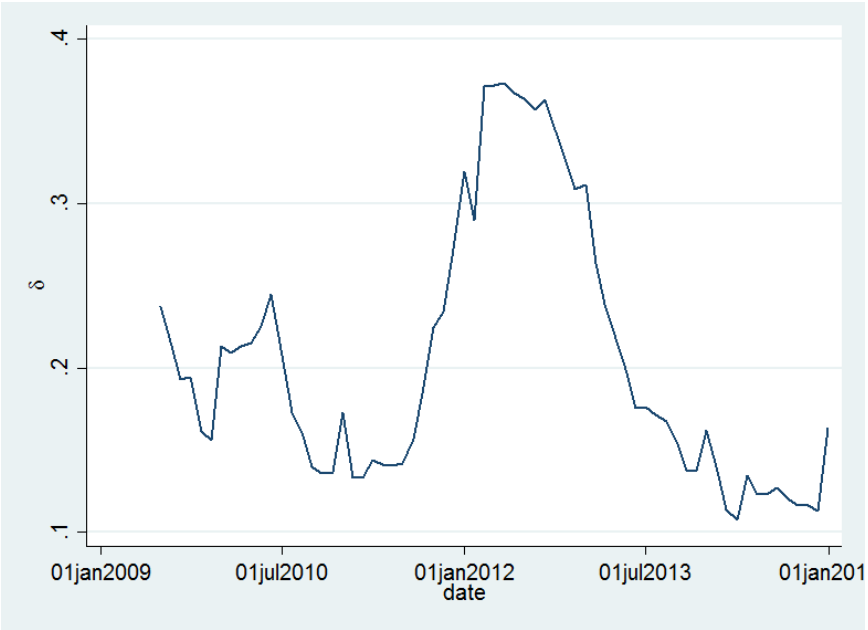
- Perfect competition in the banking sector: banks choose portfolio and offer deposit contracts to maximize the welfare of their depositors ▸ Banks problem
- Focus on **stationary equilibria** in which: ▸ Eq. Definition
  - Real quantities and other prices are constant
  - Growth rate of nominal quantities determines the inflation rate: $\frac{\phi_t}{\phi_{t+1}} = \mu$
- **Equilibrium price and quantities only depend on the couple** (μ, δ)
- **Positive analysis**: let $\mu > \beta$ and focus on the role of δ in equilibrium price determination

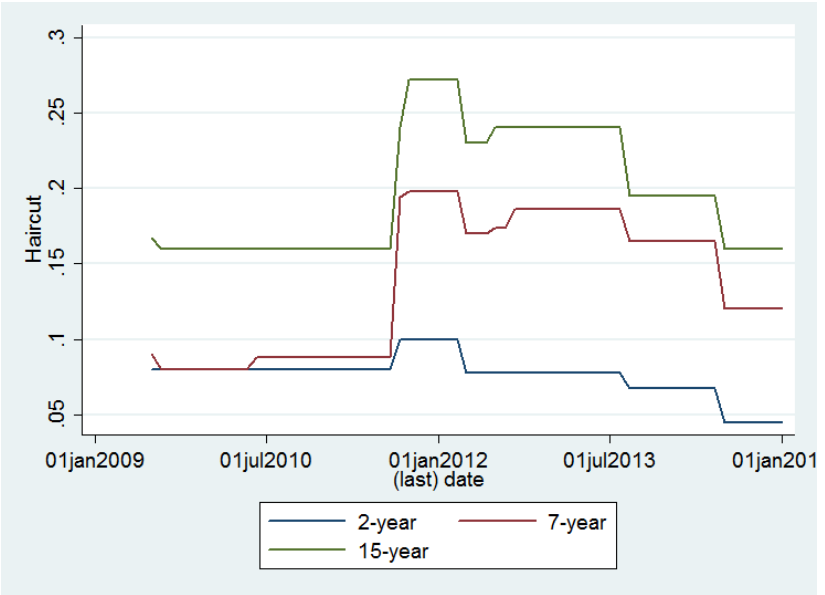
Regression with liquidity

	Panel FE	
liquidity italy	-14.03**	
	(4.128)	
haircut	1.168**	
	(0.328)	
liquidity#haircut	40.56*	
	(19.42)	
cds	0.643***	
	(0.0228)	
irs	0.956***	
	(0.0366)	
T2 ita	-4.563***	
	(0.765)	
Constant	-0.467**	
	(0.139)	
Observations	469	469
R-squared	0.943	
Marginal effects		
delta (at 25p of haircut)	-10.79***	
	(2.691)	
delta (at 50p of haircut)	-7.624***	
	(1.527)	
delta (at 75p of haircut)	-6.123***	
	(1.269)	
haircut (at 50p of liquidity)	2.173***	
	(0.323)	

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Relative liquidity and haircuts





Return

Problems of Financial Intermediaries (I)

$$\max_{\substack{m,b,a,l,\\ \{m^i,b^i,a^i\}^{i=1,2}}} -\frac{\phi_t}{\phi_{t+1}}m - \frac{\phi_t}{\phi_{t+1}}\psi_t b - p_t a + \\ +\beta\left[\frac{1}{2}F^1(m,b,a,m^1,b^1,a^1,l) + \frac{1}{2}F^2(m,b,a,m^2,b^2,a^2,l)\right]$$

- m, b real money and bond holding in $t+1$
- a amount of real asset
- $F^i(m,b,a)$: continuation value different whether bank will have a high ($i=1$) or low ($i=2$) depositors in not monitored meetings

Return

Problem of Financial Intermediaries (II)

- Type 1 bank: Return

$$F^1 = \left\{ (\rho+\varepsilon)u(q^{nm}_{1,t}) + (1-\rho-\varepsilon)u(q^{m}_{1,t}) + e^1 \right\}$$

s.t $\quad Rl \leq b^1 + (1-h)a^1$

$$q^{nm}_{1,t} = \frac{m^1 + l}{\rho+\varepsilon} : \text{consumption in not-monitored meetings}$$

$$q^{m}_{1,t} = \frac{(b-b^1) + (m-m^1) + (1-h)(a-a^1)}{1-\rho-\varepsilon} : \text{consumption in monitored meeting}$$

$$e^1 = ha + b^1 + (1-h)a^1 - Rl : \text{excess resources brought to next CM}$$

$$0 \leq a^1 \leq a, \quad 0 \leq b^1 \leq b, \quad l \geq 0, \quad m^1 \leq m$$

Problem of Financial Intermediaries (II)

- Type 1 bank: Return

$$F^1 = \left\{(\rho+\varepsilon)u(q^{nm}_{1,t}) + (1-\rho-\varepsilon)u(q^{m}_{1,t}) + e^1\right\}$$

s.t $\quad Rl \leq b^1 + (1-h)a^1$

$$q^{nm}_{1,t} = \frac{m^1 + l}{\rho+\varepsilon} : \text{consumption in not-monitored meetings}$$

$$q^{m}_{1,t} = \frac{(b-b^1) + (m-m^1) + (1-h)(a-a^1)}{1-\rho-\varepsilon} : \text{consumption in monitored meeting}$$

$$e^1 = ha + b^1 + (1-h)a^1 - Rl : \text{excess resources brought to next CM}$$

$$0 \leq a^1 \leq a, \quad 0 \leq b^1 \leq b, \quad l \geq 0, \quad m^1 \leq m$$

- Type 2 bank:

$$F^2 = \left\{(\rho-\varepsilon)u(q^{nm}_{2,t}) + (1-\rho+\varepsilon)u(q^{m}_{2,t}) + e^2\right\}$$

$$\text{s.t} \quad q^{nm}_{2,t} = \frac{m^2}{\rho-\varepsilon}, \; q^{m}_{2,t} = \frac{(b-b^2)+(m-m^2-l)+Rl+(1-h)(a-a^2)}{1-\rho+\varepsilon}$$

$$e^2 = ha + (1-h)a^2 + b^2$$

Equilibrium definition

Given a monetary policy rule (μ, δ), a supply of real asset A and a level of haircut $h \in [0, 1]$, a stationary equilibrium consists of real quantities of currency m, real interest bearing bonds b and real asset a, bank transfers m^i, b^i, a^i for each bank type $i = 1, 2$ and interbank loans l and n such that, for given an initial tax T_0 and tax rate T_t for $t = 1, 2, \ldots$, a gross interest rate on interbank market R, a bond price ψ and a asset price p, $\{m, b, a, m^i, b^i, a^i l, n\}$

i) solve problem of the financial intermediaries when $\frac{\phi_t}{\phi_{t+1}} = \mu$,
ii) prices are such that all markets clear ($l = n$, $b = m(1/\delta - 1)$ and $a = A$),
iii) the government budget constraint holds.

Return

Equilibrium prices

Proposition

In equilibrium:
i) the price of the bond ψ *is* $\frac{\beta}{\mu} \leq \psi \leq 1$;
ii) the price of the real asset is $p = h\beta + (1-h)\psi\mu$;
iii) Rate on interbank market $R = \frac{1}{\psi}$

- When $\psi > \frac{\beta}{\mu}$ and $p > \beta$ assets have **liquidity premium**
  - Since bonds and the real asset can both be used in bilateral trades, they will either both have a liquidity premium or both priced at fundamentals
- Price of real asset reflects its **pleadgeability** properties
- The **rate on the interbank market**, R, derives from a **no arbitrage condition**

Plentiful Interest Bearing Asset Equilibrium

- $\psi = \frac{\beta}{\mu} = \frac{1}{R}$ and $p = \beta$
- Both bonds and real assets are sufficiently abundant to allow first best consumption of buyers in monitored meetings and slack interbank market constraint
- FOC with respect to interbank market lending:

$$\textit{type 1 bank: } u'\left(q_1^{nm}\right) = R\underbrace{u'(q_1^m)}_{=1} \qquad \textit{type 2 bank: } u'\left(q_2^{nm}\right) = R\underbrace{u'(q_2^m)}_{=1}$$

  Interbank lending equalizes consumption of buyers in not monitored meetings $l = \varepsilon\frac{m}{\rho}$

- Real money holdings: $\frac{\mu}{\beta} = u'\left(\frac{m}{\rho}\right)$
- Equilibrium exists if $A > \bar{A}$ for any δ or for $A \leq \bar{A}$ and $\delta < \underline{\delta}(A)$

Change in δ do not influence the interbank market

Scarce Interest Bearing Asset Equilibrium

- $\frac{\mu}{\beta} < \psi < 1$ and $\beta < p < h\beta + (1-h)\mu$
- Asset not sufficient for first best consumption of buyers in monitored meetings and constraints on interbank market binds : **liquidity premium**
- Interbank market equalizes marginal utilities

$$u'(q_1^{nm}) = Ru'(q_1^m) \qquad u'(q_2^{nm}) = Ru'(q_2^m)$$

  With log utility full risk sharing: so $l = \varepsilon\frac{m}{\rho}$ and $\frac{\mu}{\beta} = u'\left(\frac{m}{\rho}\right)$

- $R = \frac{\rho/m}{1-\rho}\left[\left(\frac{1}{\delta} - 1\right)m + (1-h)A\right]$
- Equilibrium exists for A sufficiently small and $\tilde{\delta}(A) < \delta < \underline{\delta}(A)$

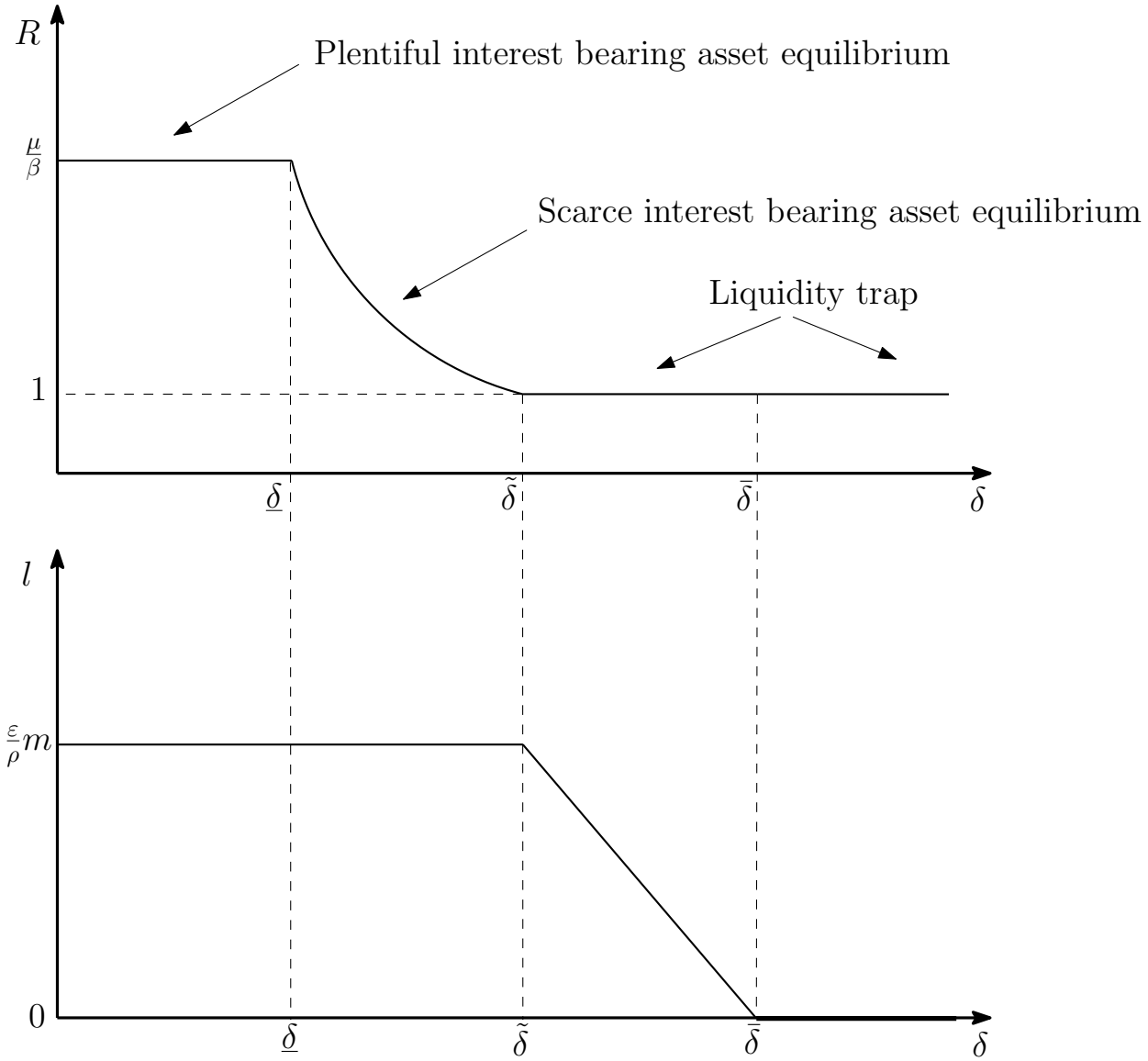
Change in δ affect the interbank market rate

Liquidity trap equilibrium

- when $\psi = 1$ and $p = h\beta + (1-h)\mu$, bonds are perfect substitute of money (real asset is not. due to haircut)
- *liquidity trap with interbank market*
  - $R = 1$, banks equalize consumption of both type of depositors
  - Increasing δ implies higher real money holdings: $\frac{\mu}{\beta} = u'\left(\frac{m}{\delta} + (1-h)A\right)$
  - Increasing δ implies more currency for both banks: less trade on the interbank market, I decreasing in δ
  - Equilibrium exists for A sufficiently small and $\tilde{\delta}(A) \leq \delta < \bar{\delta}(A)$

  Open market operations only influence borrowing on the interbank market
- *liquidity trap without interbank market*
  - enough currency also for type 1 bank, no need to access interbank market.
  - Any further increase in δ has no effect on the economy
  - Equilibrium exists for A sufficiently small and $\delta \in [\bar{\delta}(A), 1]$

Equilibrium Interbank rate and quantities



Equilibria

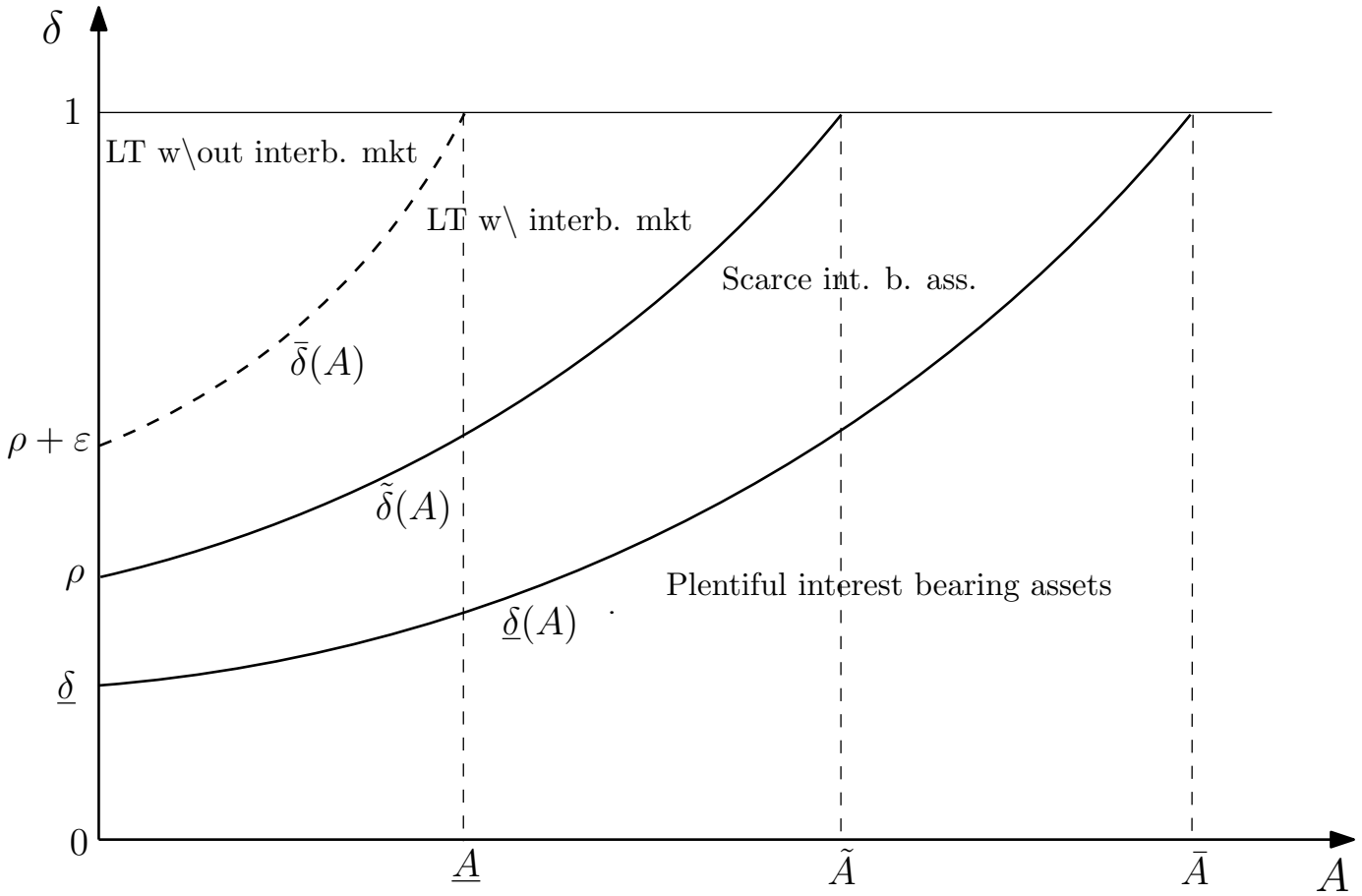
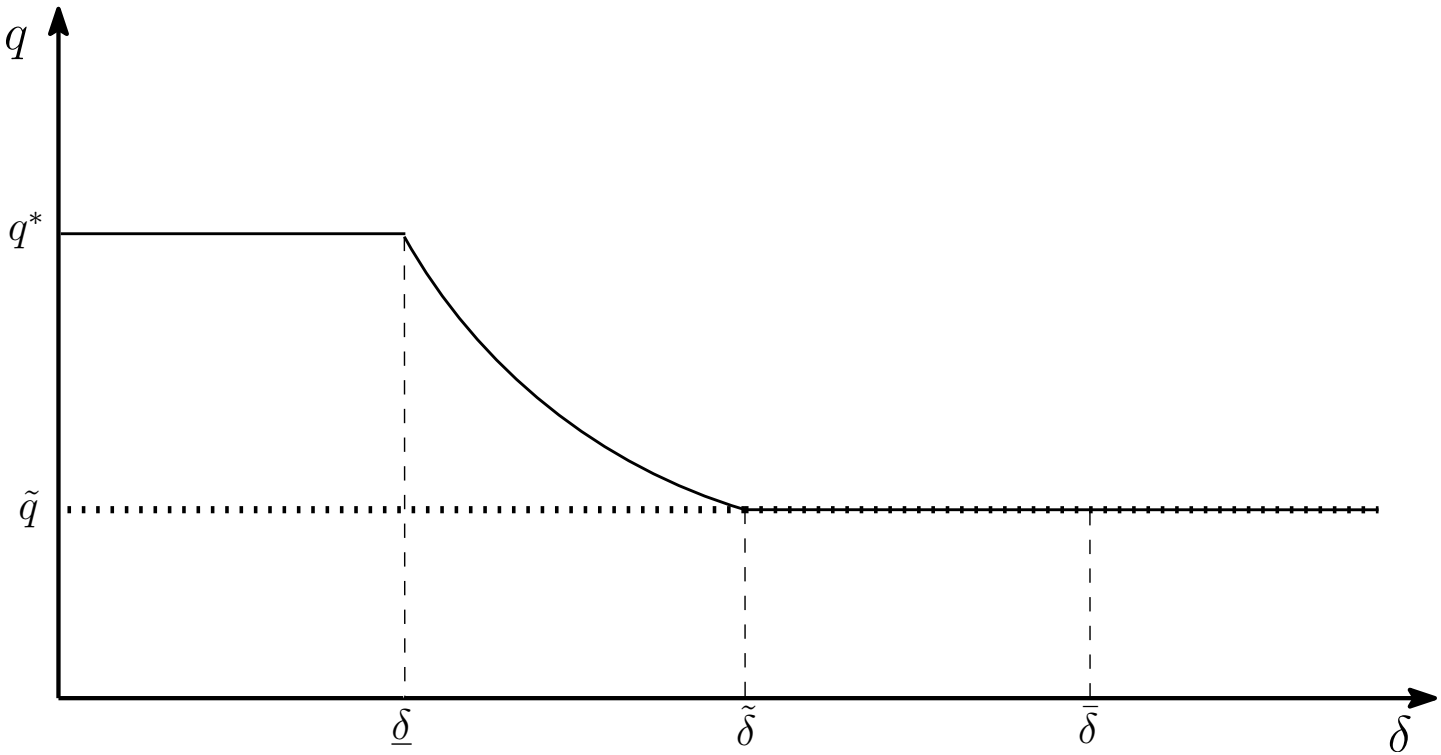


Figure: Equilibria of the model with respect to A and δ

Return

Equilibrium consumption



Return

Swap of gov't bonds with the real asset

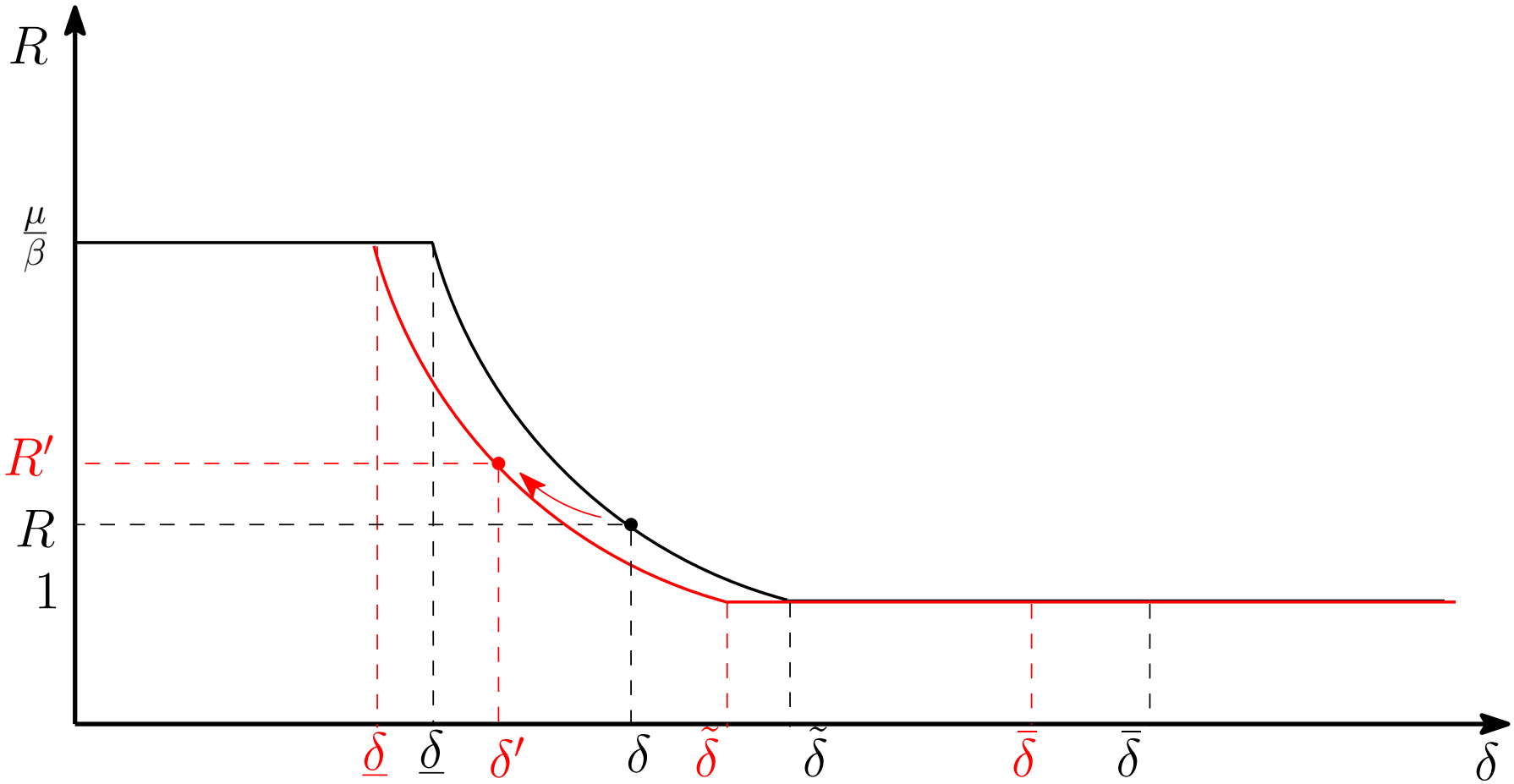
- Similar to Term Securities Lending Facilities (TSLF) program: Fed provided treasuries against Investment grade securities
- Suppose Central Bank takes in quantity A^0 of the real asset for an amount B^0 of new bonds such that $\phi\psi B^0 = pA^0$.

  What's going to be the new pledgeable amount of assets in the economy?
  - Suppose we are not in a liquidity trap, real value of money is constant
  - New pledgleable amount of asset is:

$$\pi^0 = \pi + \left[\frac{1}{\psi\mu}\left[h\beta + (1-h)\psi\mu\right] - (1-h)\right]A^0 = \pi + \frac{\beta}{\psi\mu}hA^0$$

    greater than π as long as $h > 0$
- Central Bank is taking in scarcely pleadgeable collateral and replacing with fully pledgeable one. Less scarce collateral in the economy implies that R increases.

Swap of gov't bonds with the real asset



Swap of gov't bonds with the real asset

- Implications consistent with available evidence (Fleming et al. (2010))

TABLE 2—TSLF EFFECTS ON REPO RATES AND SPREADS

	Dependent variable: change in overnight rate/spread				
Independent variable	Treasury rate	Agency rate	Agency MBS rate	Agency spread	Agency MBS spread
Constant	0.09	−0.04	−0.05	−0.13	−0.13
	(1.20)	(1.05)	(1.07)	(1.19)	(1.27)
Schedule 1	0.03	−0.01	−0.02	−0.04	−0.05
	(0.22)	(0.26)	(0.27)	(0.05)	(0.05)
Schedule 2	1.01***	0.61*	0.41*	−0.40***	−0.60**
	(0.32)	(0.33)	(0.22)	(0.11)	(0.25)
Quarter end	−42.11***	5.49	16.62**	47.60***	58.74***
	(13.26)	(5.52)	(6.53)	(13.79)	(17.14)
Quarter beginning	46.32***	−14.97	−23.28	−61.29***	−69.59***
	(15.05)	(17.39)	(16.31)	(18.57)	(19.09)
Adjusted R^2	21.1 percent	7.8 percent	6.2 percent	19.7 percent	23.3 percent

Notes: Least squares regressions of daily changes in overnight general collateral repo rates (relative to changes in the Fed funds target rate) and repo spreads (to Treasury repo rates) on the quantity of Treasury securities lent via TSLF Schedule 1 and Schedule 2 operations and on dummy variables for the first and last days of the quarter. Repo rates and spreads are in basis points, and security quantities are in billions of dollars, par value. Coefficients are reported with Newey-West standard errors in parentheses.

Increasing liquidity with bonds or real asset

- Suppose the central bank wants to introduce a given nominal amount of money in the economy, what is the effect on interbank rate if it takes in the real asset or gov't bonds?
- In both cases collateral in the economy will become more scarce, therefore rate on interbank market decreases.
- Let R^a be the interbank rate when central bank is taking in the real asset, and R^b when taking in bonds

Proposition

$R^a \geq R^b$, with equality if and only if $h = 0$

- By taking in bonds the central bank is reducing more the pledgeable collateral than when taking in the real asset. Therefore stronger decrease of the interbank rate.

Increasing liquidity with bonds or real asset