

# Overcoming Borrowing Stigma: The Design of Lending-of-Last-Resort Policies

Yunzhi Hu<sup>UNC</sup>    Hanzhe Zhang<sup>MSU</sup>

Wednesday, July 17, 2019

Stony Brook Game Theory Festival



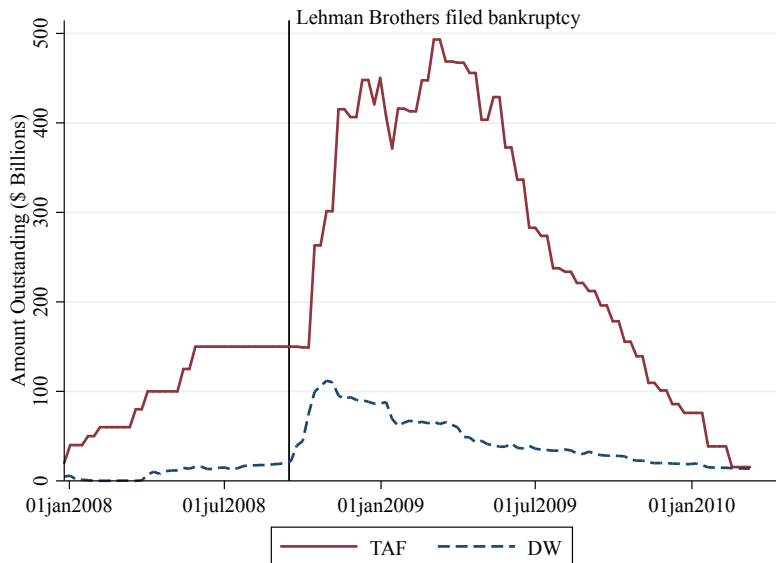
# Borrowing Stigma

- ▶ Since its creation in 1913, Fed has lent directly to banks with liquidity shortage through **discount window** (DW).
- ▶ However, in August 2007, the onset of the financial crisis, few banks borrowed from DW despite of market-wide shortage of liquidity (reflected by frozen interbank borrowing).
- ▶ This lack of DW borrowing has been widely attributed to **stigma** – concerns that, if DW borrowing were detected, depositors, creditors, and analysts could interpret it as a sign of financial weakness.

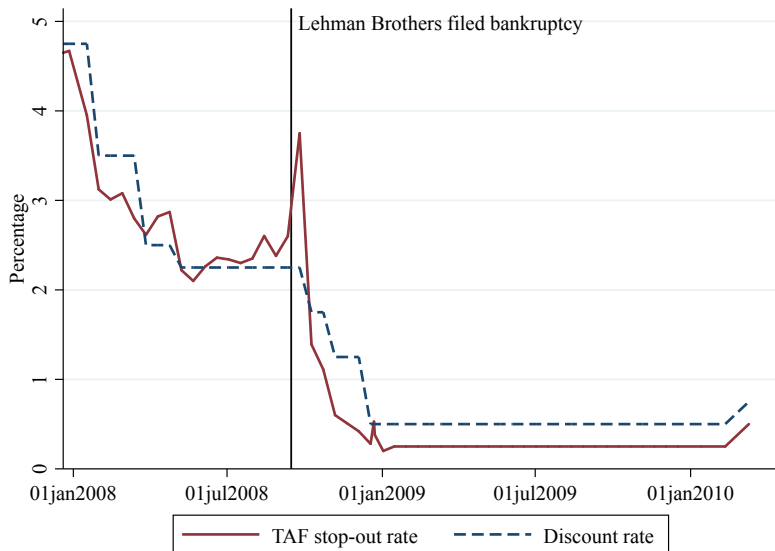
# Term Auction Facility

- ▶ In response to the lack of discount window borrowing, Fed created the **Term Auction Facility** (TAF) in December 2007.
- ▶ TAF ran sixty auctions every two weeks between December 2007 and March 2010 to lend collateralized loans to banks.
  - On Monday, banks phoned their local Fed regional banks to submit their bids specifying their interest rate (and loan amount) and posting collaterals.
  - On Tuesday, Fed secretly informed the winners and publicly announced the stop-out rate, determined by the highest losing bid (or the reserve price if the auction was under-subscribed).
  - On Thursday, Fed released the funds to the banks.
  - Throughout the whole auction process, the banks were free to borrow from DW.
  - Every Monday, each regional Fed published total lending from last week; banks may be inferred from these summaries or other channels.

# DW versus TAF Borrowing



# DW versus TAF Rates



# Overview

We provide a theoretical framework to

- ▶ endogenize stigma associated with borrowing from DW and TAF
- ▶ explain how TAF could encourage participation and borrowing
- ▶ explain how TAF bids could be higher than the discount rate
- ▶ predict empirically verified implications that
  - DW borrowers were worse than TAF borrowers
  - TAF winners were worse than TAF losers

# Economy

- ▶ There are  $n$  banks.
- ▶ Each bank has a privately known financial situation (type)  $\theta \in [0, 1]$ , i.i.d. distributed  $F$ .
- ▶ Each bank's borrowing benefit is  $b(\theta)$ , increasing in its financial weakness,  $b' < 0$ .
  - For example,  $b(\theta) = (1 - \theta)R$ . Each bank is endowed with one unit of illiquid assets that will generate return  $R$  upon maturity but nothing if liquidated early. There is probability  $\theta$  that the liquidity shock hits a type- $\theta$  bank.

# Discount Window

- ▶ DW offers a loan at interest rate  $r_D$ , the so-called **discount rate**.
- ▶ A bank who takes the loan gets  $b(\theta) - r_D - k_D$ .
- ▶ **Stigma**  $k_D = k(G_D)$  is determined by the distribution  $G_D$  of types borrowing from DW.
  - $k$  is monotonic:  $k(G) > k(H)$  if  $G$  is strictly first-order stochastically dominated by  $H$ .
- ▶ A bank borrows iff

$$b(\theta) - r_D - k_D \geq -k_N.$$

- ▶ Cutoff  $\theta_1$ : banks  $[0, \theta_1]$  borrow

$$b(\theta_1) - r_D - (k_D - k_N) = 0.$$



# Stigma

- Borrowing from DW

$$G_D(\theta) = \frac{F(\theta)}{F(\theta_1)} \quad \forall \theta \leq \theta_1$$

- No borrowing

$$G_N(\theta) = \frac{F(\theta) - F(\theta_1)}{1 - F(\theta_1)} \quad \forall \theta > \theta_1$$

- $G_N$  FOSDs  $G_D$ :  $k_D > k_N$ .

# Perfect Bayesian Equilibrium in DW-Only Economy

## PBE

- ▶ Each bank chooses borrowing to maximize expected payoff given beliefs  $G_D$  and  $G_N$ .
- ▶ Beliefs  $G_D$  and  $G_N$  are consistent with aggregate borrowing behavior.

## Equilibrium in DW-Only Economy

Any  $\theta_1$  that satisfies

$$b(\theta_1) - r_D - [k_D(\theta_1) - k_N(\theta_1)] = 0.$$

characterizes an equilibrium. There is a unique equilibrium if

$$b'(\theta_1) - [k'_D(\theta_1) - k'_N(\theta_1)] < 0.$$

# Discount Window and Term Auction Facility

- ▶ In reality, TAF ran an auction every other Monday and DW was always available.
- ▶ DW is available in period 1:  $b(\theta) - r_D - k_D$ .
- ▶ TAF is available in period 2:  $\delta b(\theta) - E\beta - k_A$ .
  - TAF awards  $m$  units of liquidity.
  - There is a minimum bid  $r_A$ .
  - Each bank submits a bid  $\beta \geq r_A$  specifying the interest rate it is willing to pay.
  - The interest rate is determined by the highest losing bid (or reserve price if fewer than  $m$  bids).
- ▶ DW is also available in period 2 after TAF:  $\delta b(\theta) - r_D - k_D$ .
- ▶ Not borrowing: 0.

# Unique PBE in the DW-TAF Economy

There is a unique PBE in which

- ▶ banks  $[0, \theta_D]$  borrow from DW1,
- ▶ banks  $[0, \theta_A]$  bid in TAF, and
- ▶ banks  $[0, \theta_2]$  borrow from DW2

if regularity conditions are satisfied.

## DW2

- ▶ A bank borrows from DW2 (when it has not borrowed from previous programs) iff

$$\delta b(\theta) - r_D - k_D \geq 0.$$

- ▶ Cutoff  $\theta_2$ : banks  $[0, \theta_2]$  borrow from DW2,

$$\delta b(\theta_2) - r_D - k_D = 0.$$

# TAF Bids

- Each bank bids maximal willingness to pay

- Banks

$$\delta b(\theta) - \beta(\theta) - k_A = \begin{cases} \delta b(\theta) - r_D - k_D & \theta \leq \theta_2 \\ 0 & \theta > \theta_2 \end{cases}$$

- Bids

$$\beta(\theta) = \begin{cases} r_D + k_D - k_A & \theta \leq \theta_2 \\ \delta b(\theta) - k_A & \theta > \theta_2 \end{cases}$$

- Cutoff  $\theta_A$ : Bank participates iff

$$\delta b(\theta) - r_A - k_A \geq 0$$

# TAF Payoffs

Payoffs given  $H(\tau)$  distribution of highest loser's type  $\tau$

$$u_A(\theta; H) = \begin{cases} \delta b(\theta) - \int_0^{\theta_2} [\beta(\tau) + k_A] dH(\tau) - \int_{\theta_2}^1 [\beta(\tau) + k_A] dH(\tau) & \theta \leq \theta_2 \\ \int_{\theta}^1 [\delta b(\theta) - \beta(\tau) - k_A] dH(\tau) & \theta > \theta_2 \end{cases}$$

$$u_A(\theta; H) = \begin{cases} \delta b(\theta) - \int_0^{\theta_2} \delta b(\theta_2) dH(\tau) - \int_{\theta_2}^1 \delta b(\tau) dH(\tau) & \theta \leq \theta_2 \\ \int_{\theta}^1 [\delta b(\theta) - \delta b(\tau)] dH(\tau) & \theta > \theta_2 \end{cases}$$

- ▶ A bank borrows from DW1 iff

$$b(\theta) - r_D - k_D - u_A(\theta; H) \geq 0.$$

- ▶ Slope is

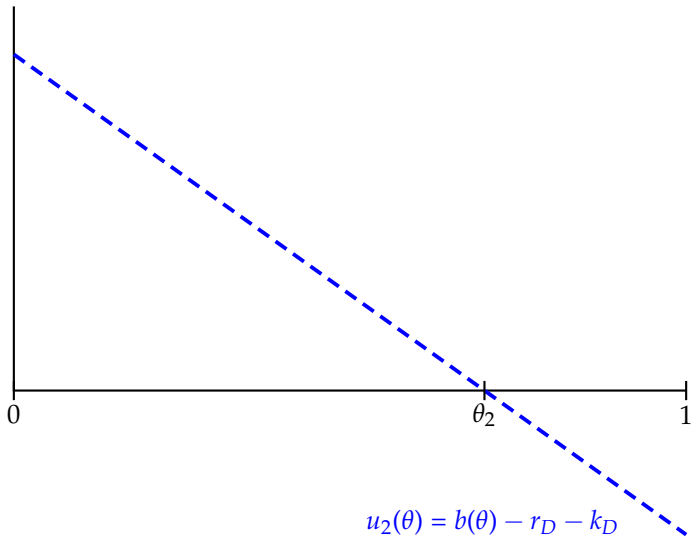
$$b'(\theta) - u'_A(\theta; H) = b'(\theta) - \begin{cases} \delta b'(\theta) & \theta \leq \theta_2 \\ \delta b'(\theta)(1 - H(\theta)) & \theta > \theta_2 \end{cases} < 0$$



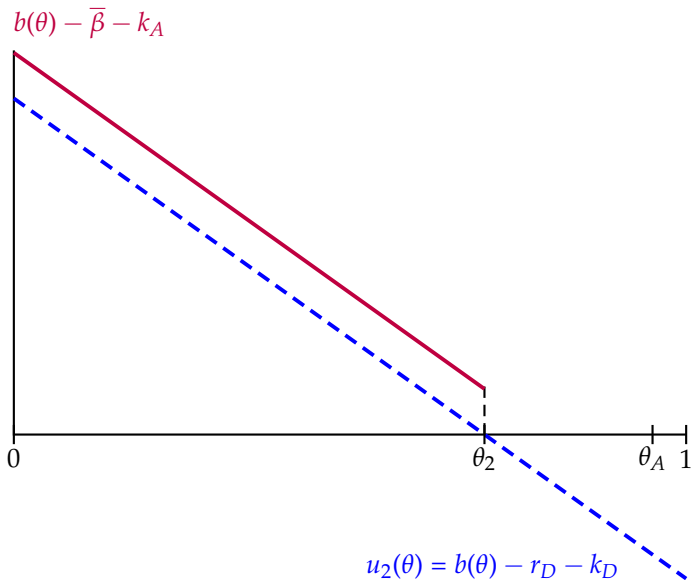
## Case 1 (large $\delta$ ): TAF+DW



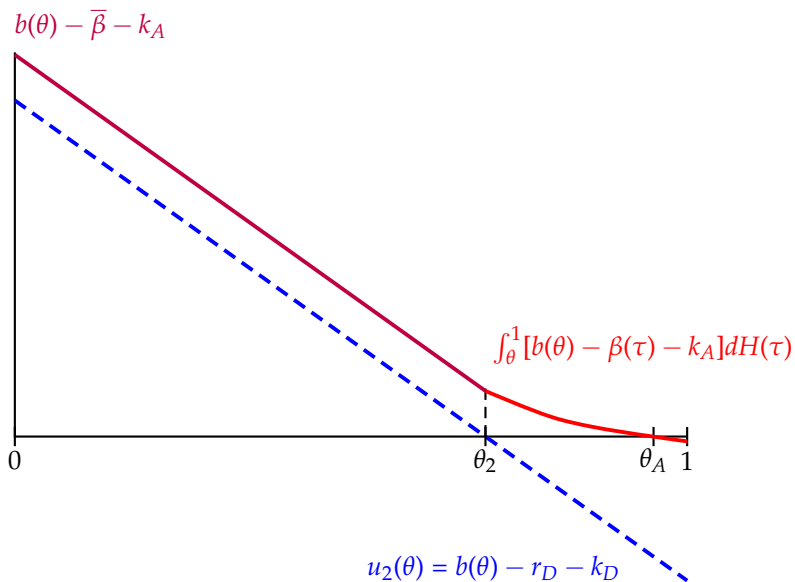
## Case 1 (large $\delta$ ): TAF+DW



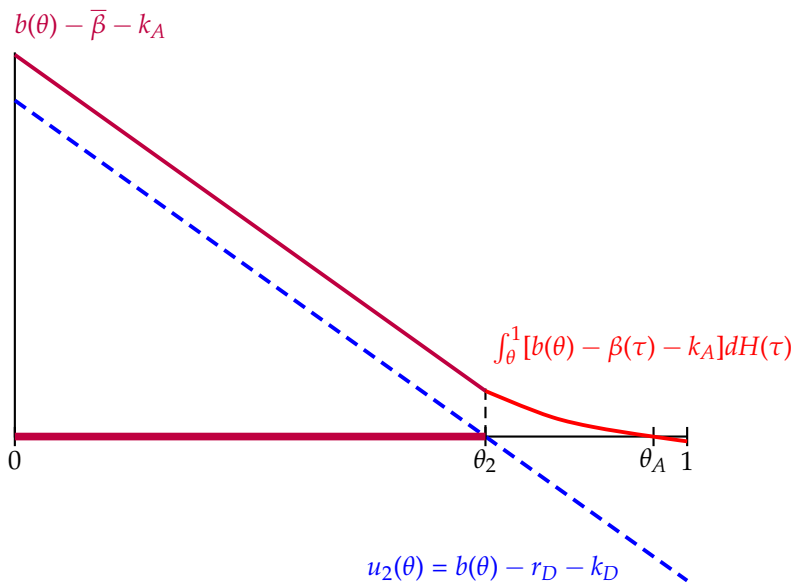
## Case 1 (large $\delta$ ): TAF+DW



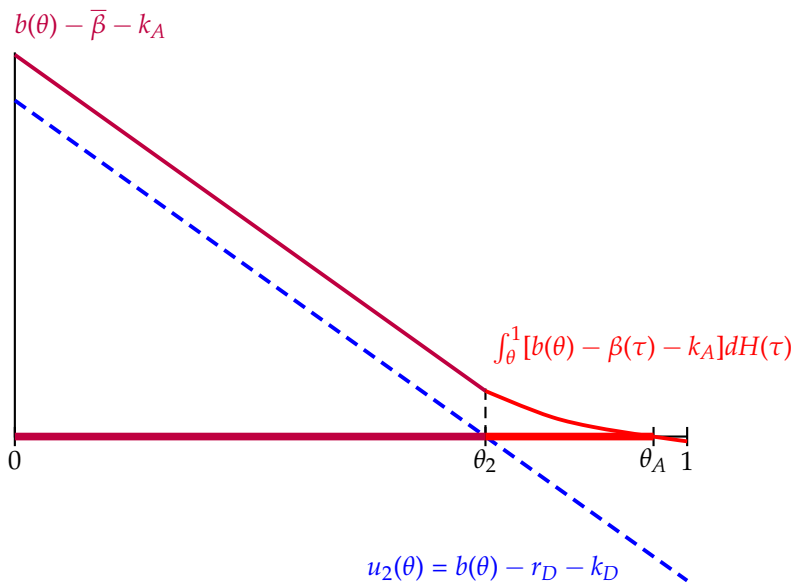
## Case 1 (large $\delta$ ): TAF+DW



## Case 1 (large $\delta$ ): TAF+DW



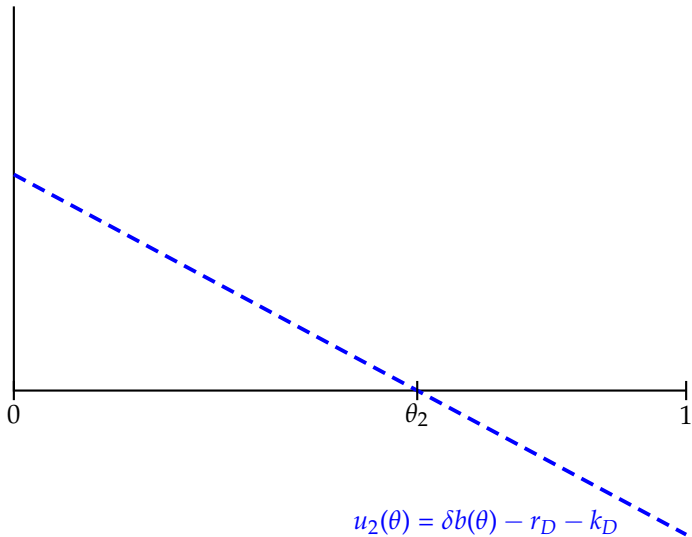
## Case 1 (large $\delta$ ): TAF+DW



## Case 2: DW+TAF+DW

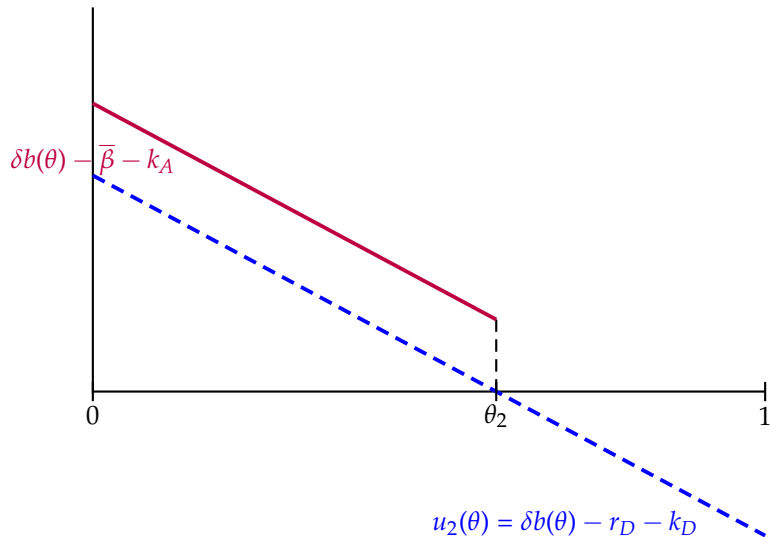


## Case 2: DW+TAF+DW

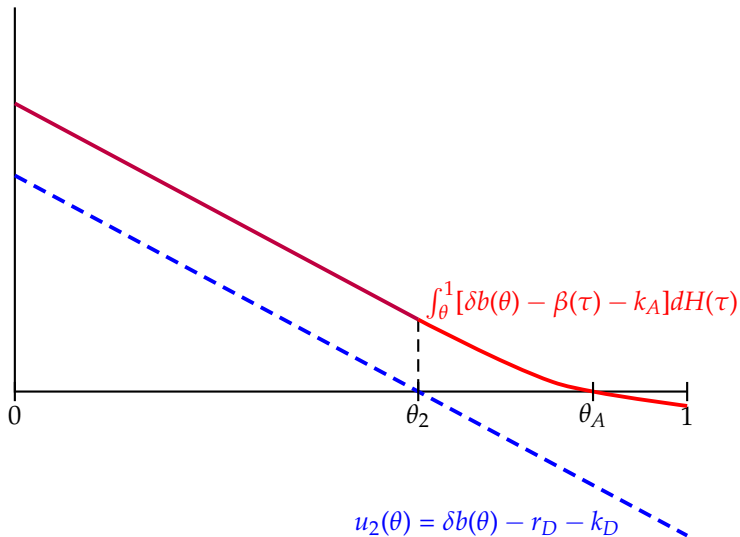




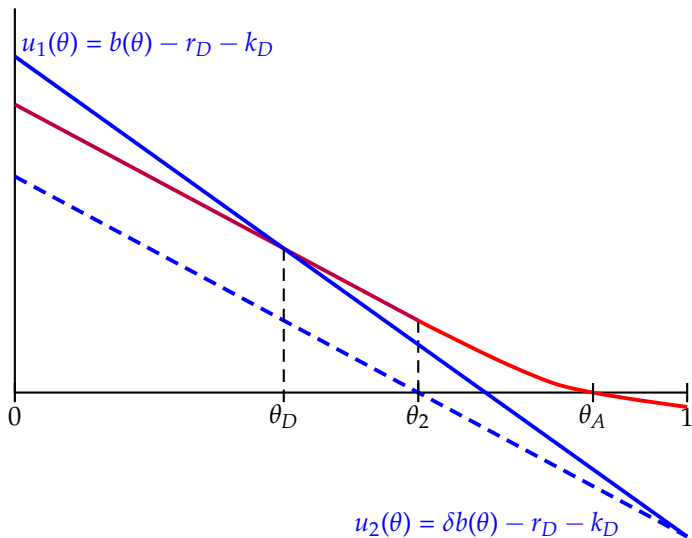
## Case 2: DW+TAF+DW



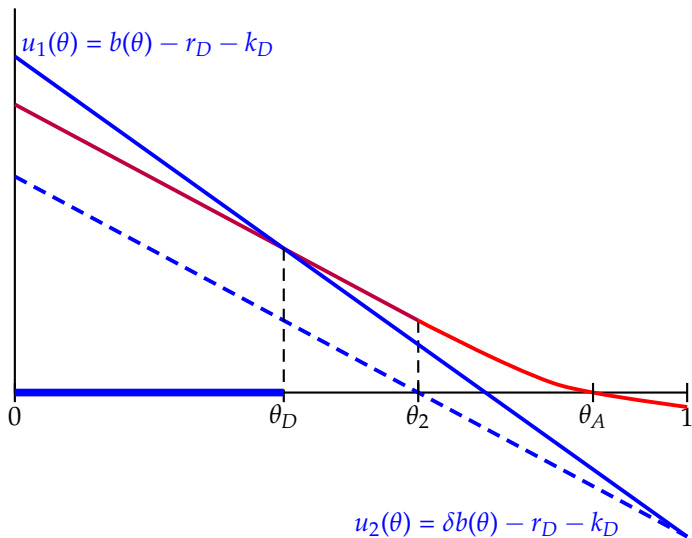
## Case 2: DW+TAF+DW



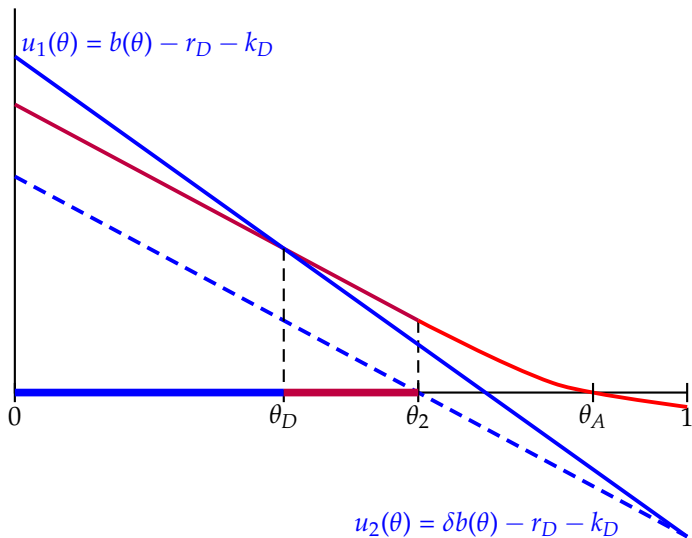
## Case 2: DW+TAF+DW



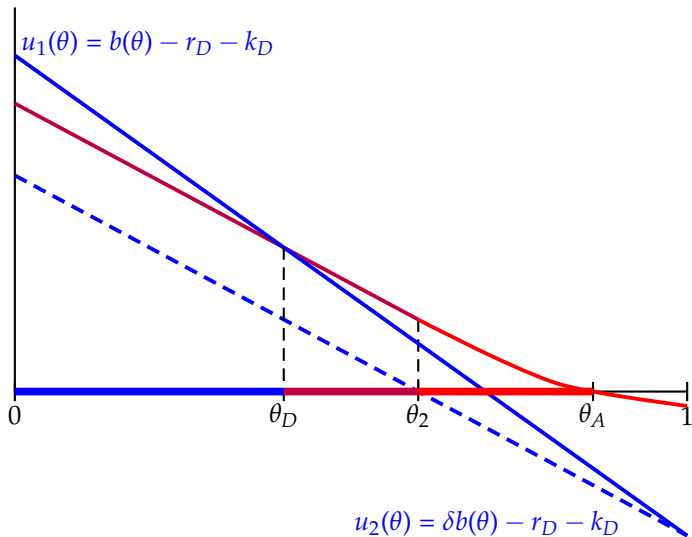
## Case 2: DW+TAF+DW



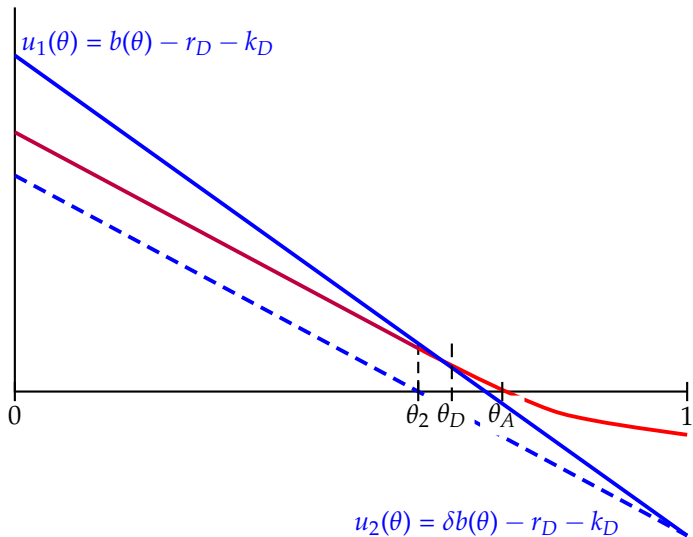
## Case 2: DW+TAF+DW



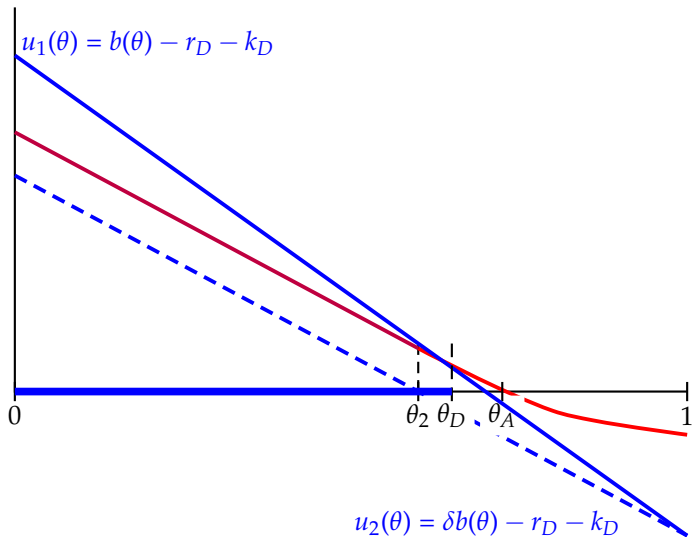
## Case 2: DW+TAF+DW



### Case 3: DW + TAF

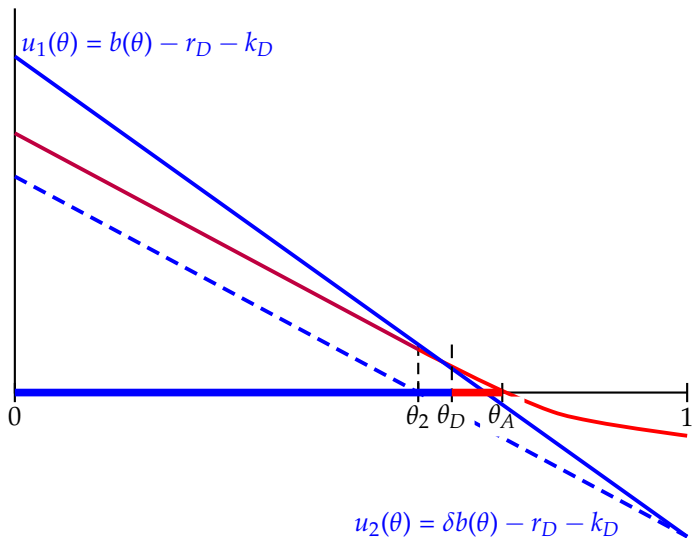


### Case 3: DW + TAF

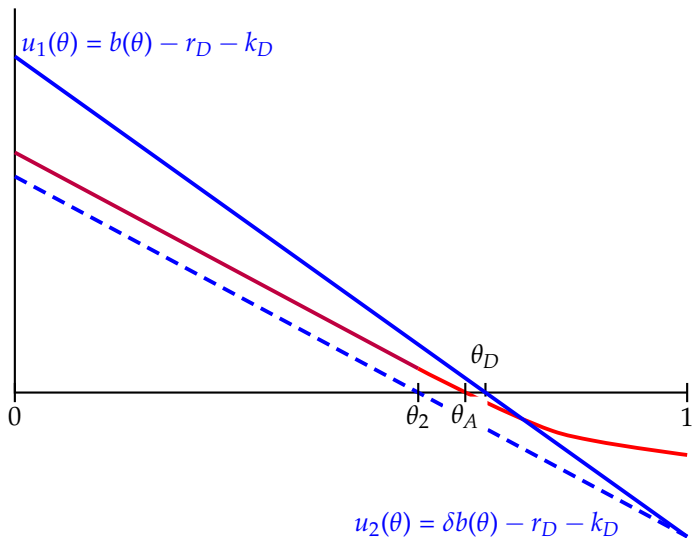




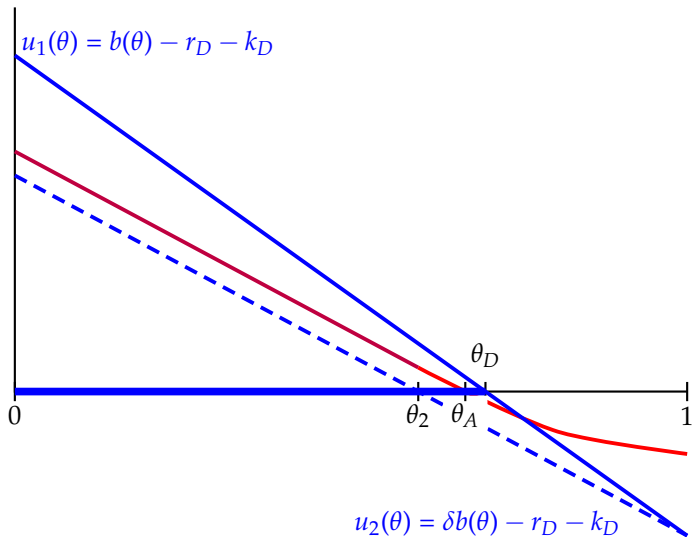
### Case 3: DW + TAF



## Case 4 (small $\delta$ ): DW Only



## Case 4 (small $\delta$ ): DW Only



# Testable Implications

- ▶ Key testable implications
  - DW banks were worse than TAF banks
  - TAF winners were worse than TAF losers
  - DW1 banks were worse than DW2 banks
- ▶ Our tests center around two main ideas:
  1. Compare banks' fundamentals ( $\theta$ ) in different groups
  2. Compare market reactions ( $k$ ) to different groups

# Data

## ► Discount Window

- Federal Reserve released under court order (March 31, 2011), extracted by Bloomberg.
- Aug 1, 2007 to Apr 30, 2010
- Daily borrowing through DW, TAF, and other programs
- (Pledged collaterals not available)

## ► Term Auction Facility

- Obtained through FOIA request
- Covering all 60 auctions from Dec 17, 2007 to Mar 8, 2010
- Bidding rates, amount, pledged collaterals of both winners and losers

## DW vs TAF: Tier 1 Capital

1% increase in tier 1 capital/asset ratio is associated with 2.5-3.2% less borrowing from DW.

	(1)	(2)	(3)
Tier 1 Capital/Assets	-3.176*** (1.047)	-2.720* (1.524)	-2.496** (1.058)
(mean) size	-0.061*** (0.009)	-0.790*** (0.193)	-0.064*** (0.009)
borrower FE	No	Yes	No
time FE	No	No	Yes
industry FE	Yes	No	Yes
country FE	Yes	Yes	Yes
N	561	561	561
R <sup>2</sup>	0.113	0.558	0.151

# DW vs TAF: Tier 1 Capital

1% increase in tier 1 capital/risky-asset ratio is associated with 2-2.6% less borrowing from DW.

	(1)	(2)	(3)
Tier 1 Capital/Risky-weighted Assets	-2.577*** (0.772)	-2.105* (1.170)	-2.069** (0.804)
(mean) size	-0.059*** (0.009)	-0.747*** (0.194)	-0.062*** (0.009)
borrower FE	No	Yes	No
time FE	No	No	Yes
industry FE	Yes	No	Yes
country FE	Yes	Yes	Yes
N	561	561	561
R <sup>2</sup>	0.116	0.558	0.152

## Within TAF: Collaterals

Banks who bid higher in TAF pledged collateral with higher haircuts, including corporate market instruments, non-agency MBS, and ABS.

	(1)	(2)	(3)
High-rate bidders	0.150*** (0.009)	0.122*** (0.009)	0.026*** (0.009)
Constant	0.134*** (0.006)	0.202*** (0.053)	0.049 (0.047)
auction FE	No	Yes	Yes
G-SIB FE	No	No	Yes
Foreign FE	No	No	Yes
Sample	Full	Full	Full
N	4804	4804	4804
R <sup>2</sup>	0.051	0.087	0.345



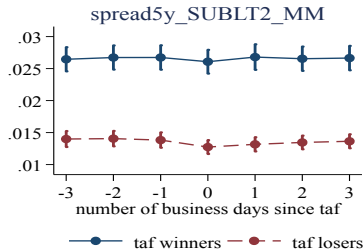
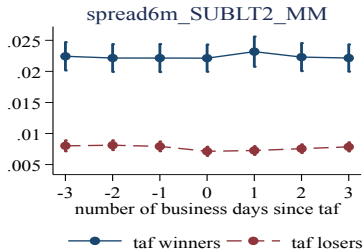
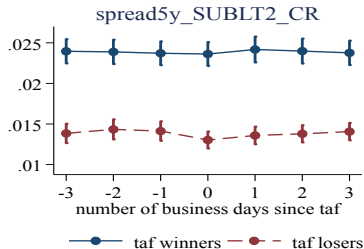
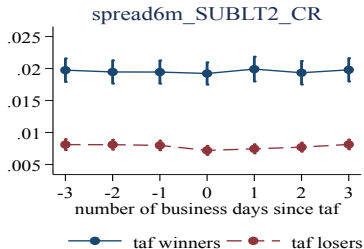
## Within TAF: Subsequent Borrowing

Winners were more likely to bid in the next two auctions.

	(1)	(2)	(3)
Winner	0.032** (0.016)	0.078*** (0.019)	0.059*** (0.019)
Constant	0.822*** (0.015)	0.722*** (0.046)	0.690*** (0.046)
auction FE	No	Yes	Yes
G-SIB FE	No	No	Yes
Foreign FE	No	No	Yes
Sample	Full	Full	Full
N	4855	4855	4855
R <sup>2</sup>	0.001	0.085	0.095

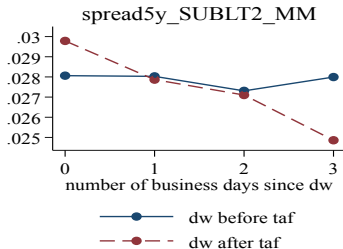
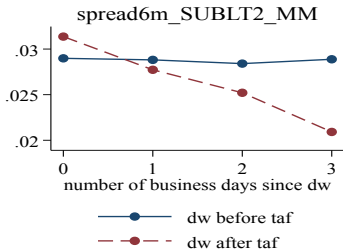
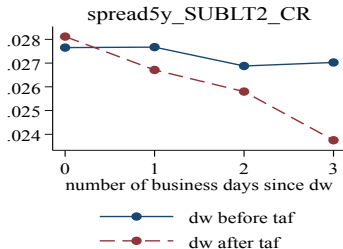
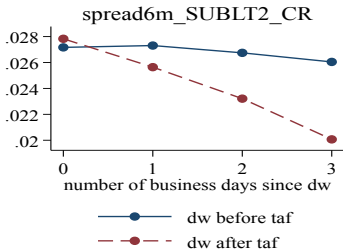
# Within TAF: CDS Spreads

TAF winners had higher CDS spreads than TAF losers.



# DW1 vs DW2: CDS Spreads

DW1 banks had higher CDS spreads than DW2 banks.



# Market Reaction to DW and TAF Borrowing

Discount window borrowing was associated with negative cumulative abnormal returns, more so if the borrowing occurred shortly before a TAF would be held.

	(1) DW	(2) DW1	(3) DW2	(4) TAF
Constant	-0.009*** (0.002)	-0.015* (0.008)	0.004 (0.007)	-0.005 (0.004)
N	2948	209	257	720

# Market Reaction to DW and TAF Borrowing

The cumulative abnormal returns were more negative if a borrower had a higher balance to market cap ratio.

	(1)	(2)	(3)	(4)
	DW	DW1	DW2	TAF
Balance/Mkt Cap	-0.011*** (0.004)	-0.105*** (0.030)	-0.049*** (0.008)	0.034 (0.048)
Constant	-0.012 (0.009)	-0.024 (0.016)	0.006 (0.011)	0.001 (0.006)
N	2948	209	257	720

Note: the coefficients are multiplied by  $10^3$ .

# Summary

- ▶ Constructed a model with endogenous DW and TAF stigma.
- ▶ Explained why TAF encouraged participation and high borrowing rates.
- ▶ Empirically verified that DW banks were worse than TAF banks, and TAF winners were worse than TAF losers, and DW1 banks were worse than DW2 banks.

Thank you!